METAL-PATTERN MAKING

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Metal-Pattern Making

By

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AND

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METAL-PATTERN MAKING
Parts 1–3

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NOTE.—This book is made up of separate parts, or sections, as indicated by their titles, and the page numbers of each usually begin with 1. In this list of contents the titles of the parts are given in the order in which they appear in the book, and under each title is a full synopsis of the subjects treated.

METAL-PATTERN MAKING, PART 2
(*Continued*)

METAL-PATTERN MAKING, PART 3

METAL-PATTERN MAKING, PART 3
(*Continued*)

METAL-PATTERN MAKING

(PART 1)

Serial 2233A Edition 1

MATERIALS, EQUIPMENT, AND CONSTRUCTION

NATURE AND MATERIALS OF METAL PATTERNS

INTRODUCTION

1. Advantages of Metal Patterns.—Metal patterns have the following advantages:

First, *durability*. A pattern made of metal will retain its size and shape for a greater number of castings than will a pattern made of wood.

Second, *the cost of castings made from metal patterns is less.* With a few exceptions, metal patterns are cast from an original, or *master pattern*. The cost and time required for the casting of metal patterns from a master pattern is less than the cost and time required to make the same number of wooden patterns. One reason for this is that castings made from metal patterns, if carefully molded, are all exact duplicates of the original, or master, pattern.

Third, *rapidity of production of castings.* Duplicate metal patterns can be arranged in groups on the same pattern plate so as to make a number of castings in each mold.

Fourth, *accuracy and finish of the castings produced.* Metal patterns can be made to conform with the working drawing to within one-thousandth inch, thereby insuring a casting that is more accurate than it is possible to make from a wooden pattern. The metal, having no coarse grain such as found in wood, takes a very smooth finish, resulting in turn in a better finished casting.

2. Master Patterns.—A master pattern is a pattern from which a number of duplicate metal working patterns are cast. The materials from which master patterns are made include wood, plaster of Paris, sheet brass, sheet lead, and white metal. As comparatively few castings are made from a master pattern, the latter is made as economically as possible. For general purposes, a wooden master pattern made of pine is used. When the casting is of uniform thickness, like the clamp shown in Fig. 1, the master pattern can be built up of sheet brass or white-metal parts held together by solder. If only one metal pattern is required, no master pattern is made, but the pattern

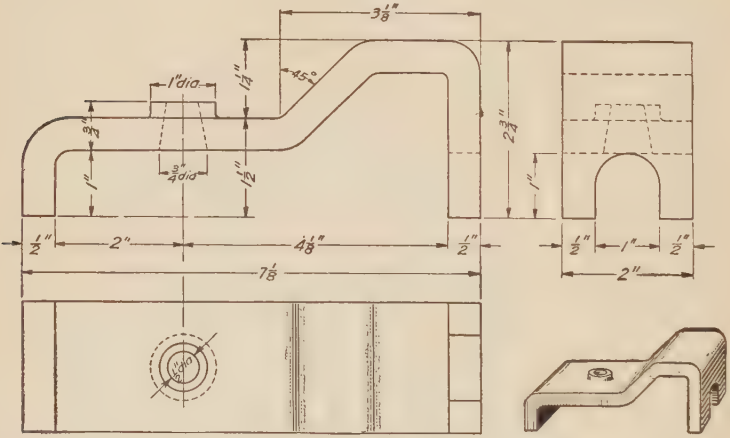


Fig. 1

is made of sheet metal. If the casting is of uniform thickness but has a curved surface as exemplified by the gear case shown in Fig. 2, it is difficult to make the pattern of sheet metal, and in such a case a master pattern is made of plaster of Paris.

Another type of master pattern is machined out of solid metal. Two examples of machined master patterns are shown in Fig. 3 (*a*) and (*b*). In view (*a*) is shown a master pattern of a metal handle which is turned in a lathe, the flat faces being milled in a milling machine, while in view (*b*) is shown a master pattern of an ornamental casting which is milled out of thick sheet metal, after the outside shape has been sawed

and filed to the required outline. Sheet lead is sometimes used to make master patterns but their shape is easily destroyed due to the softness of the metal.

3. Metal Working Patterns.—Metal working patterns are made in a variety of forms. The single form, known as the *hand pattern,* is used to make one casting in each mold. This type of pattern is used when only a limited number of castings

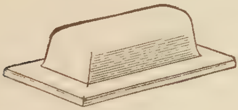


FIG. 2

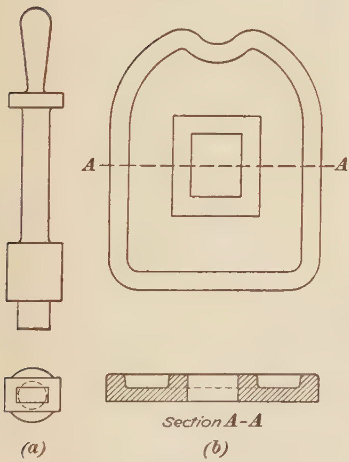


FIG. 3

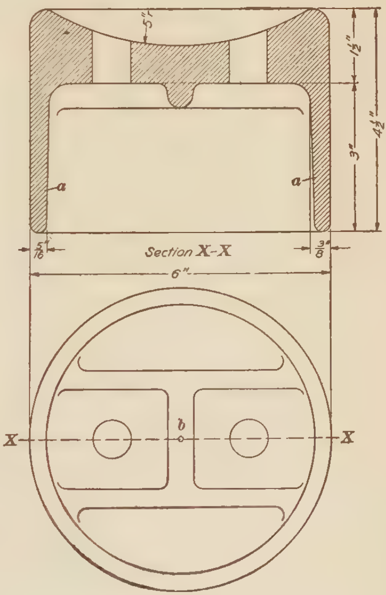
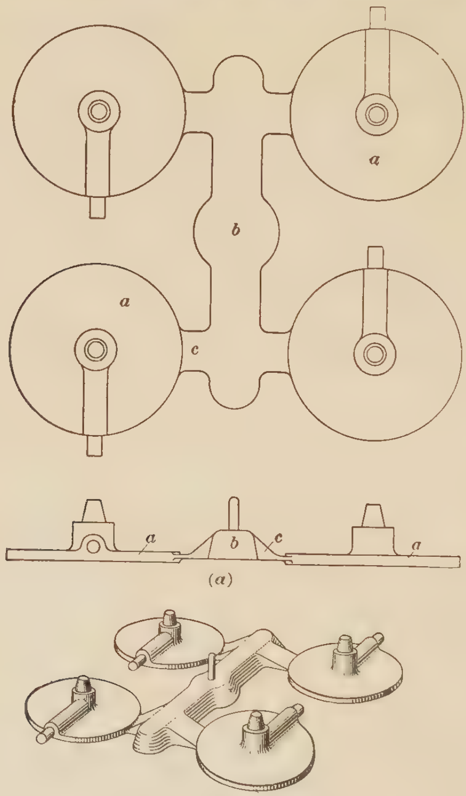


FIG. 4

is required and the general pattern dimensions or design do not permit the use of a wooden pattern. An example of a single, or hand, metal pattern of a valve piston is shown in Fig. 4. The cylindrical shape and the thin walls *a* of the pattern make it impractical to use a pattern made of wood. The hole *b* is for inserting a tapered pin or draw spike by which the pattern is removed from the mold.

4. Multiple or Gated Metal Patterns.—When a large number of small castings are required, it is often possible to

increase production by connecting a number of metal patterns to a common runner, as in Fig. 5 (*a*). In this example the patterns *a*, view (*b*), are connected to the runner *b* by means of the gates *c*. In most cases the group of patterns, runner, and gates, known as a *gate of patterns,* can be mounted on a plate



(*a*)

(*b*)

FIG. 5

or in a frame, which is used on a molding machine. Such castings as handles, wedges, clamp frames, levers, etc., are often gated as in the example shown in Fig. 5. The gates *c* are also known as *branches,* or *pattern connections.*

5. Mounting of Metal Patterns for Molding Machine Use. When the number of castings required warrants the use of a

molding machine, several metal patterns may be mounted on one plate or frame, which is then used on the machine. The type of molding machine mountings depends on local foundry conditions, such as the kind of flask and of molding machine used. For molding machines the patterns should be mounted in such a way that the least skill is required to make the mold. The following methods of mounting metal patterns for use on molding machines are employed: Steel-plate mounting, frame mounting, aluminum-plate mounting, and special pattern mounting.

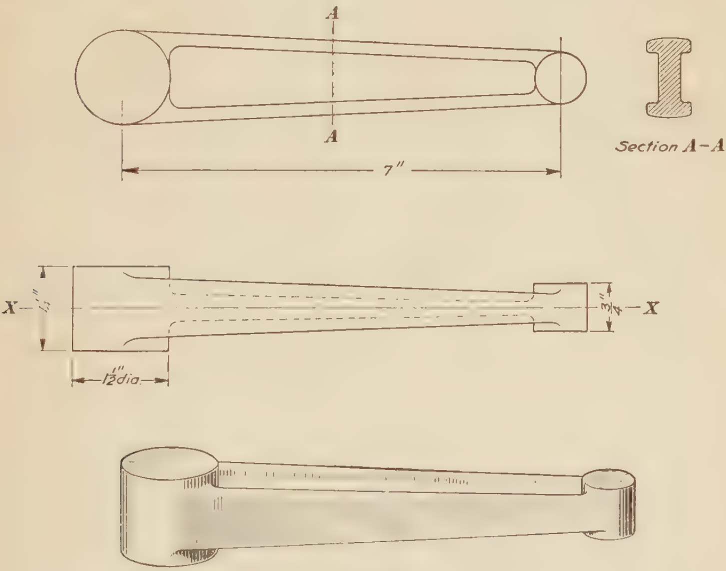


FIG. 6

6. Steel-Plate Mounting of Metal Patterns.—In steel-plate mounting the pattern is split in halves and each half is mounted on a steel plate which is fastened in a fixture on the molding machine. Metal patterns of light or medium weight, which can be conveniently split into halves and which have a straight parting line, such as the pattern of the connecting-rod shown in Fig. 6, may be mounted in this way, especially when a very large number of castings is to be made. The pattern is split along the parting line *XX*, and a number of half-patterns are

mounted on a steel plate, as shown in Fig. 7. Both the cope and the drag are made from the same plate. The patterns *a*

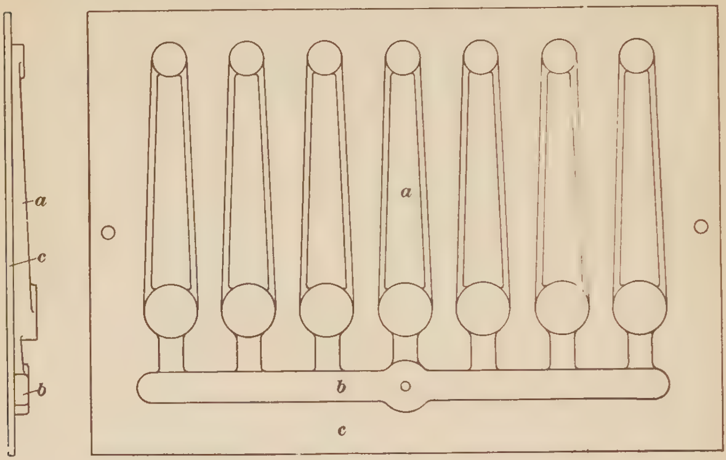


FIG. 7

are all gated to a common runner *b* and are fastened to a plate *c*. The plate *c* is made of $\frac{1}{8}$-inch sheet steel, and a practical rule is

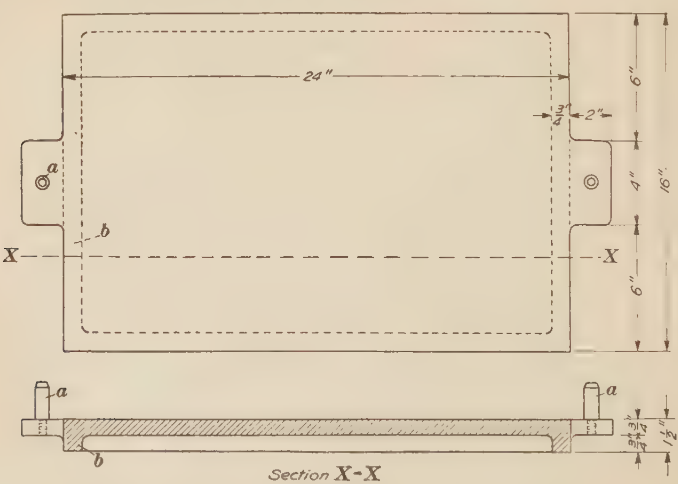


FIG. 8

that a plate of this thickness, 13 inches wide and 18 inches long can support a combined pattern weight of 60 pounds. For

patterns weighing more than is allowed for the $\frac{1}{8}$-inch steel plate, such as automobile-cylinder and transmission-case patterns, an aluminum plate cast from a wooden master pattern is used. One form of aluminum plate is shown in Fig. 8. The plate has guide pins *a* to aline it with the flask and is reinforced by a rib *b*.

7. Frame Mounting.—When the parting line of a metal pattern of light or medium weight is irregular so that it is not possible to mount the patterns on a steel plate, the patterns are gated, and the gates are fastened to a frame, which is mounted on the molding machine. In Fig. 9 is shown an example of

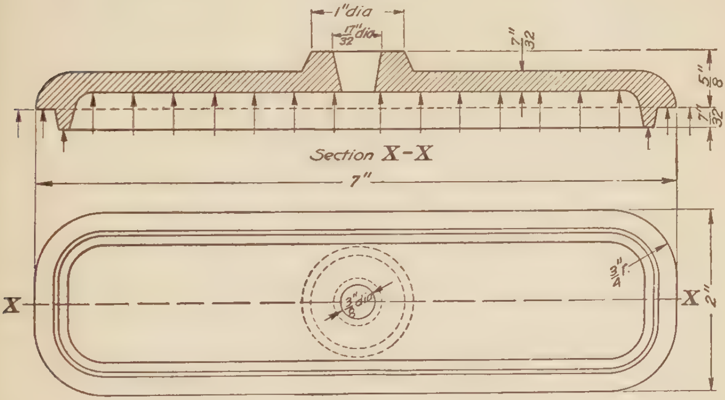


FIG. 9

the type of pattern that is mounted in a frame. The parting line of the pattern, which is that of an oilhole cover for a bearing, is shown by the arrows in the sectional view.

8. Cast Aluminum-Plate Mounting.—Patterns having irregular parting lines may be cast as a part of an aluminum pattern plate. A plate of this type is shown in Fig. 10. The drag mold is rammed up on one side of the plate, which is then rolled over and the cope is rammed up on the other side. The steel pins *a* line up both parts of the flask with the plate. Such plates are also known as *match plates*.

9. Special Mountings for Metal Patterns.—In some cases the metal patterns may be mounted in specially designed fix-

tures, which are used in a molding machine. The object of such mountings may be the elimination of all dry-sand cores, or the

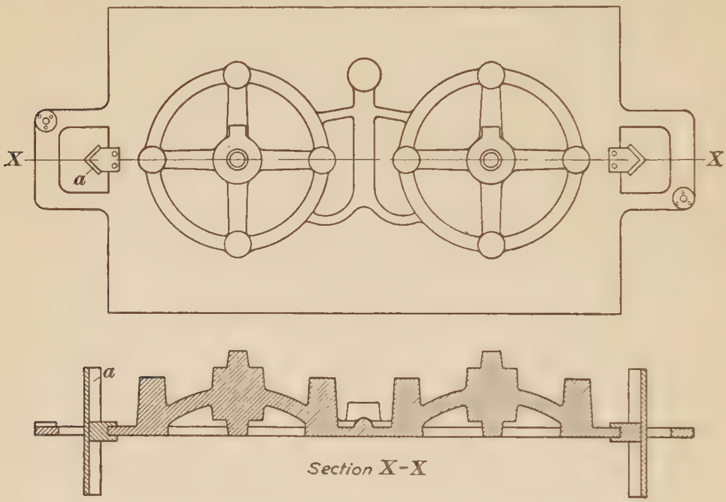


Fig. 10

placing of a certain part of the pattern in the cope or drag mold, or the use of a special way of gating the pattern, or for other reasons. This type of mounting is costly and is only used

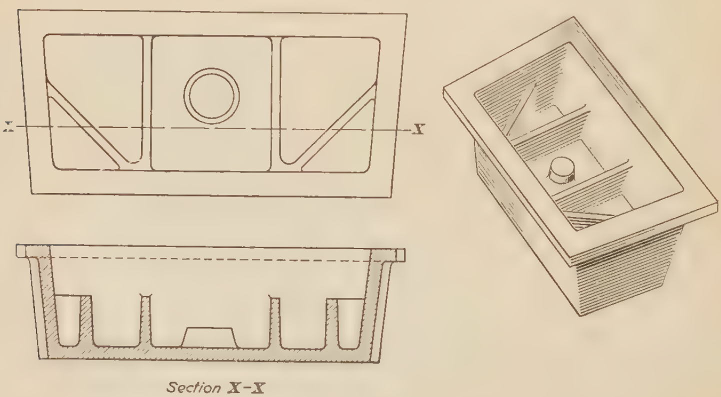
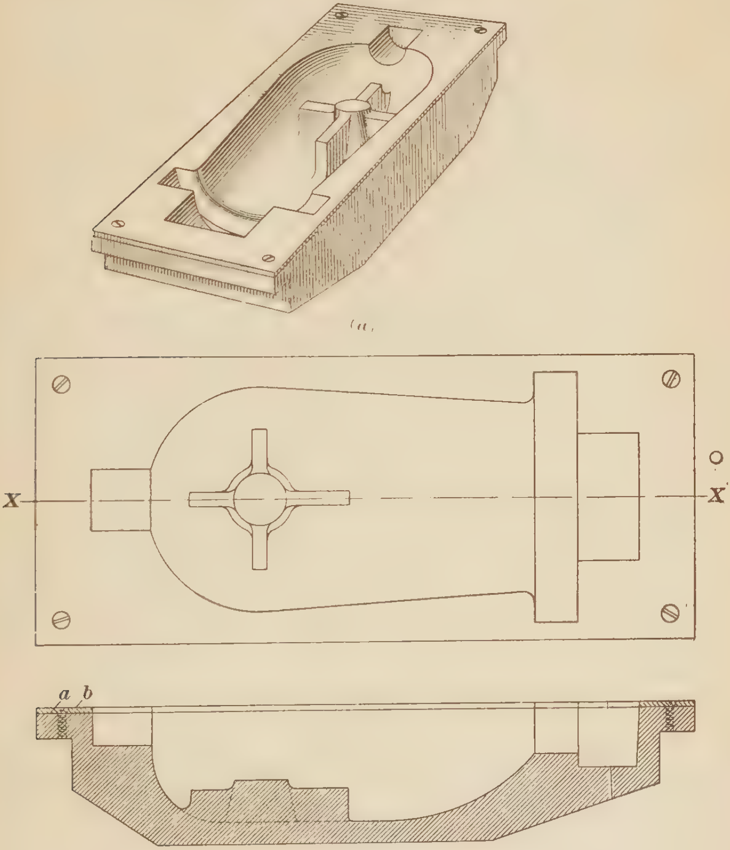


Fig. 11

when it is desired to eliminate the expensive labor of the skilled molder and coremaker.

10. Metal Core Boxes.—Core boxes of intricate design that are to be used many times are often made of metal. Cast iron, brass, or aluminum are the materials used in core box construction. When the box has a complicated design, a wooden



(a)

Section X–X

(b)

FIG. 12

master pattern is first made and a metal casting is made from it. The casting is finished by machining or hand scraping. When the core box is of simple design, it may be made of solid metal by a milling, drilling, or turning process or a combination of

these processes. When a core box can be machined easily and a substantial box is required, cast iron is used in the construction. Cast brass is used when the box has narrow pockets and thin walls or partitions which must be very smooth so that the core can be removed without breaking. A typical design for a brass core box is shown in Fig. 11. Aluminum is used when the core box is of large dimensions or the design is such that the box cannot be machined easily and must be scraped to size by hand. This type of core box is exemplified in Fig. 12 (*a*). The face *a*, view (*b*), is sometimes covered with a plate *b* of sheet steel to protect it from being injured by the steel bar of the coremaker during the operation of striking off the excess core sand.

11. Draft on Metal Patterns and Core Boxes.—The draft on metal patterns and core boxes is less than that used on patterns and core boxes made of wood, as the metal can be finished very smooth. Metal patterns mounted on molding machines are usually given a draft of .025 inch per inch, while hand and gated patterns must have at least .05 inch per inch draft. Small pockets or indentations must have a greater amount of draft, which is determined by the location of the pocket or the amount of sand surrounding the pocket. The extra amount of draft helps in holding the sand that is in the pocket. In extreme cases the draft may amount to as much as $\frac{1}{8}$ inch per inch.

MATERIALS FOR MAKING METAL PATTERNS

12. White Metal.—An alloy of lead, tin, and antimony, known as *white metal*, is often used for making metal patterns. The best results are obtained from an alloy containing tin 100 pounds, or 78 per cent.; antimony 18 pounds, or 14 per cent.; and lead, 10 pounds, or 8 per cent. This alloy has very little shrinkage; and in some cases, when conditions are such that rapping will not damage the mold, the shrinkage is taken care of by rapping the pattern sufficiently to make the mold enough larger so that the white-metal casting will be of the same size as the pattern. In such cases, no allowance need be made on the master pattern to compensate for shrinkage of the white-

metal working pattern. White metal melts at 600 degrees Fahrenheit.

13. Aluminum.—Aluminum alloyed with zinc is used for metal patterns when both hardness and light weight of the pattern are desired. This alloy when made in the proportion of 80 pounds, or 89 per cent., of aluminum to 10 pounds, or 11 per cent., of zinc, has a shrinkage of $\frac{5}{32}$ inch per foot. It is used for general metal pattern work. When alloyed in the proportion of 92 pounds of aluminum to 8 pounds of zinc, the composition is suited for match plates and long thin patterns, as this alloy is soft, and castings made from it will not check or crack in cooling. Aluminum alloy melts at about 1,200 degrees Fahrenheit.

14. Brass.—Brass is used for metal patterns where thin partitions and ribs require a very stiff and smooth pattern. A soft yellow brass is best as it is very easily finished. The shrinkage of yellow brass is $\frac{3}{16}$ inch per foot, and the melting point is about 1,600 degrees Fahrenheit.

15. Gray Iron.—Gray cast iron is used for patterns when a large number of castings is to be made from the pattern and where a thin shell instead of a solid pattern can be used. The shrinkage of cast iron is $\frac{1}{8}$ inch per foot, and the melting point is about 2,200 degrees Fahrenheit.

16. Solder.—Solder is used for joining patterns to gates or runners, for patching white-metal patterns, and in the construction of sheet brass master patterns. A good composition of solder is made in the proportion of 80 pounds of tin and 60 pounds of lead. This composition, when sweated into the joint, produces a more durable joint than the ordinary tinner's half-and-half solder. A composition, known as aluminum solder, is made in the proportion of 86 pounds of tin, 9 pounds of zinc, and 5 pounds of aluminum. It is used to fill cracks and cavities in aluminum patterns and core boxes, and to sweat together aluminum parts.

17. Sheet Brass.—Sheet brass is used to build up master patterns and to make templets. Hard sheet brass is preferable

to soft, as soft or annealed, brass is tough and not easily cut or filed. The sizes of sheets usually kept in stock vary in thickness by $\frac{1}{32}$ inch from $\frac{1}{32}$ inch to $\frac{5}{16}$ inch.

18. Sheet Steel.—Sheet steel, or boiler plate, is kept in stock in thicknesses of $\frac{1}{8}$ inch and $\frac{1}{4}$ inch, and is cut to 4-foot squares to be made into pattern plates for use on molding machines. It is also used to face core boxes to prevent excessive wear.

19. White-Metal Sheets.—White metal in the form of sheets, which are cast from a wooden pattern, is used to build master patterns and to make additions or changes on white-metal or brass patterns. The sheets are generally made 10×24 inches in size, and in the following thicknesses: $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, and $\frac{3}{4}$ inch.

20. Cold-Rolled Steel.—Cold-rolled steel rods are used for shafts, flask pins, and reinforcements on metal patterns and core boxes. Steel rivets are also made of round cold-rolled stock. Round stock having diameters of $\frac{1}{4}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, and 1 inch, as well as square stock in $\frac{1}{4}$-, $\frac{1}{2}$-, $\frac{5}{8}$-, and $\frac{3}{4}$-inch sizes are commonly used.

21. Tool Steel.—Tool steel rods having diameters of $\frac{1}{4}$, $\frac{1}{2}$, and $\frac{3}{4}$ inch are used to make small tools, scrapers, and dowel pins. This stock is also known as drill rod.

22. Brass Rod.—Brass rods having diameters of $1\frac{1}{2}$, 1, $\frac{3}{4}$, $\frac{5}{8}$, $\frac{3}{8}$, and $\frac{1}{4}$ inch, and gauge Nos. of 10, 20, 30, and 40, are used for making bosses, small brass patterns, and rivets.

23. Plaster of Paris.—Plaster of Paris is used to make master patterns, working patterns, and filling for hollow patterns. When a very intricate pattern is to be made, it is sometimes the practice to make the mold of plaster of Paris, and set plaster of Paris cores in the mold, in order to test the pattern and core-box equipment. Only the best grade of plaster is used. Plaster expands about $\frac{1}{64}$ inch per foot in setting, and must be stored in a dry place.

24. Clay.—Modeler's clay is used to make temporary master patterns and for the reproduction of irregular surfaces. It consists of a mixture of clay with from 10 to 30 per cent. of glycerine, by weight, according to the desired consistency, and must be stored under a damp canvas or burlap cover.

25. Wax Filler.—A prepared wax made of 1 quart of linseed oil, 8 pounds of beeswax, 8 pounds of whiting, and 1 pound of rosin is used to fill holes and crevices in metal master patterns and to make fillets. The wax is mixed and poured into paper cylinders about $1\frac{1}{2}$ inches in diameter and 6 inches long. When the wax has cooled, the paper is removed. To apply the wax to a pattern, it is necessary to heat the pattern slightly so the wax will adhere, after which it is applied with a hot iron. Prepared wax is comparatively hard when set and is preferable to pure beeswax.

26. Soldering Acid.—The acid commonly used in soldering metal patterns is sulphuric acid containing as much zinc as it will dissolve. This acid is very strong, and its vapor is injurious to the hands and face. It also causes stains and rust on tools. A soldering acid that gives very good results and is not so strong as sulphuric acid consists of a mixture of 9 pounds of zinc chloride, 1 quart of hydrochloric acid, sometimes called muriatic acid, and 9 gallons of water. All soldered patterns or parts should be washed in clean water after soldering, to prevent corrosion around the joints.

27. Sandpaper and Emery Cloth.—Sandpaper is used to finish white-metal and iron patterns, and plaster that has been thoroughly dried. It is not effective on aluminum as it clogs up and the abrasive particles soon wear off. The grades usually found in the metal pattern shop are Nos. 00, 0, $\frac{1}{2}$, and 1. Emery cloth is used to finish brass and aluminum patterns and core boxes. Fine, medium and coarse grade sheets, 9×11 inches in size, are generally kept in stock.

28. Metal-Pattern Cleaners.—Sulphuric acid is used to clean brass and white-metal patterns and core boxes. Metal patterns that have been used a long time become corroded, due

to damp foundry sand and other causes. To clean the pattern, it is first washed in boiling water and then dipped in a vat of sulphuric acid, after which the acid is washed off with warm water, a brush being used to remove the loosened dirt and corrosion.

29. Rivets.—Steel, brass, and copper rivets of various sizes are used in metal-pattern making. If a stock of such rivets is not on hand, rivets may be made from steel, brass, or copper rod with the aid of the rivet header shown in Fig. 13. The header consists of two pieces *a* and *b* made of hardened

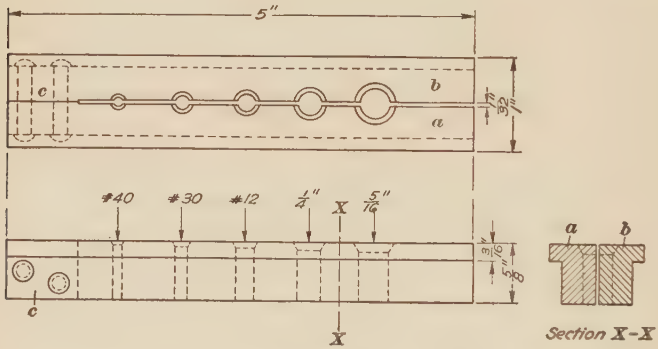


Fig. 13

and tempered tool steel which are riveted together at one end *c* as shown, and are provided with holes having diameters corresponding to the following sizes of rivet rod: No. 40, No. 30, No. 12, $\frac{1}{4}$ inch, and $\frac{5}{16}$ inch. The first three sizes are measured by gauge. These sizes are generally kept in stock. To make a rivet a rod of the same diameter as that of the required rivet is placed in the proper hole and firmly held by clamping the free end of the header in a vise. After the rod has been adjusted in the hole, a head may be riveted on the end of the rod in the countersunk hole provided for that purpose. Releasing the vise allows the rivet to be removed. Only one head is formed on the rivet in the header, the other head being made on the work with the rivet in place. Usually each patternmaker's bench is equipped with a rivet header to enable the patternmaker to make the rivets as needed on the particular job on hand, instead

of keeping a large assortment of rivets of various sizes and lengths in stock. Brass rod to be used as rivets must first be annealed.

30. Screws and Bolts.—Screws and bolts are used to fasten metal patterns to pattern plates, for patching and fastening gated patterns to frames for use in molding machines, etc. In most metal-pattern shops, with the exception of those using patterns of automotive parts, United States Standard flat-head machine screws of the following sizes and number of threads per inch are commonly used: No. 6-32, No. 8-32, No. 10-32, No. 12-24, $\frac{1}{4}''$-20, and $\frac{3}{8}''$-16. In addition to these, the following sizes of United States Standard hexagon-head bolts are usually kept in stock: $\frac{1}{4}''$-20, $\frac{5}{16}''$-18, $\frac{3}{8}''$-16, and $\frac{1}{2}''$-13. Some concerns using metal patterns for automotive parts use the United States Standard screws and bolts as given here. Others use the S. A. E. Standard screws and bolts, as follows: $\frac{1}{4}''$-28, $\frac{3}{8}''$-24, $\frac{5}{16}''$-24, and $\frac{1}{2}''$-20.

31. Core-Box Dowel Pins.—When a metal core box is made in two halves, a number of dowel pins are used to keep the halves alined. Two types of dowel pins are used. The pin shown in Fig. 14 is made of $\frac{3}{8}$-inch diameter cold-rolled steel with its point tapered 7°, and is used in core boxes that are made for a limited number of cores. When a large number of cores is required from an aluminum core box, pins with a threaded steel bushing should be used. The pin fits into the steel bushing and in this way an enlargement of the pin hole in the soft metal of the core box, due to wear, is prevented. The use of these pins is shown in the illustrations of patterns and core boxes.

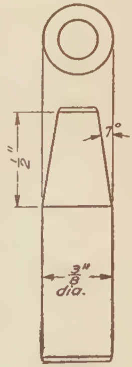


FIG. 14

EQUIPMENT FOR MAKING METAL PATTERNS

32. General Equipment.—A shop making metal patterns is usually equipped with a number of work benches on which most of the finishing and fitting of patterns and core boxes is done by the use of files and scrapers, the work being held in a

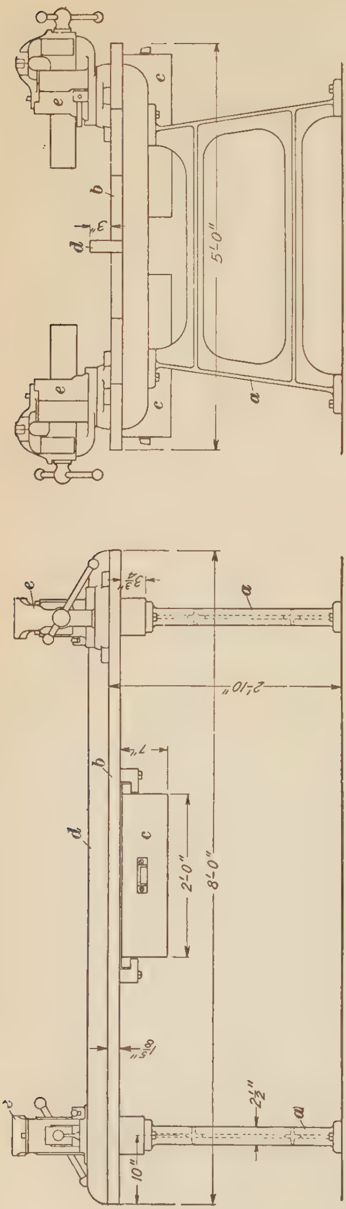


Fig. 15

vise attached to the bench. In addition to the benches, the shop usually contains one or more of the following machines: Shapers, milling machines, drill presses, lathes, grinders, and saws. Small tools such as drills, taps, reamers, chisels, files, precision tools, etc., are carried in a centrally located stock room and are issued to the patternmaker as needed.

33. Patternmaker's Bench. A typical form of bench for making metal patterns is shown in Fig. 15. It is made with cast-iron standards *a* and has a hardwood top *b*. The rest of the wooden structure of the bench is made of yellow pine, and includes the tool drawer *c* and the board *d*, which divides the top in two sections, so that the bench can be used by two patternmakers each using one of the vises *e*. The vise used on such a bench is usually a 5-inch-jaw machinists' vise having a swivel base so that the pattern can be held at any desired angle. Small hand tools are kept in the drawer *c*, and precision tools are generally kept in separate compartments in a special tool box.

34. Machine Tools Used in Making Metal Patterns. Some of the machine tools commonly used in shops making metal patterns will now be described, together with their uses.

A 24-inch shaper is used to machine metal patterns to size, face off metal core boxes, and to machine the sides of metal patterns and core boxes so as to provide draft. As the shaper is faster than the milling machine, it is more generally used.

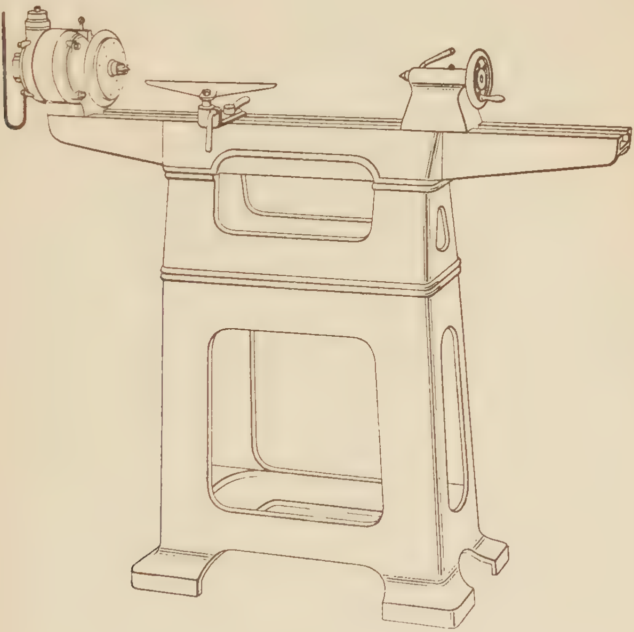


FIG. 16

A universal cutter-head milling machine equipped with a complete assortment of cutters may be used to form metal patterns and core boxes of all shapes.

A small sensitive drilling machine is used to drill all small holes. The maximum capacity of the drill chuck should be about $\frac{1}{4}$ inch. A radial drill having a maximum chuck capacity of 1 inch is used to drill the larger holes, and to counterbore and countersink holes in metal patterns, core boxes, and pattern plates.

35. A motor-head speed lathe, such as shown in Fig. 16, with a 6-inch swing is used to turn small bushings, shafts, pins, and small metal patterns, and to bore out small metal core boxes. A 16-inch engine lathe is used to turn patterns and bore out core boxes that are too large or heavy to be handled in the speed lathe. For turning the largest odd-shaped metal patterns and core boxes, a 22-inch gap lathe is used in some shops. This lathe may also take the place of the 16-inch engine lathe.

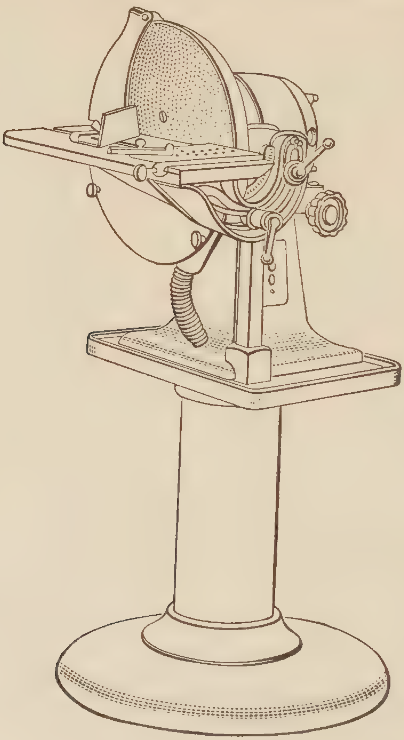


Fig. 17

36. A disk grinder with one wheel, as shown in Fig. 17, or with two wheels, is used to remove excess metal from the flat faces of metal patterns and core boxes. The wheels are steel disks to which No. 2 or No. $2\frac{1}{2}$ emery cloth, carborundum cloth, or garnet paper is cemented. When the abrasive is worn off or clogged with metal particles, it may be removed from the

steel disks by soaking in hot water, after which a new abrasive sheet is glued to the disks. The work table may be raised, lowered, or tilted. The dust is drawn through a flexible hose into the column and may be collected in a receptacle either indoors or outside the shop.

A two-wheel tool grinder, one form of which is shown in Fig. 18, is used to sharpen the patternmaker's tools, including chisels, scrapers, drills, etc. One of the wheels is usually of fine grain and hard grade, and the other is of medium grain and soft grade. The diameter of the wheels is about 8 inches. A one-half horsepower enclosed motor is used. The machine is

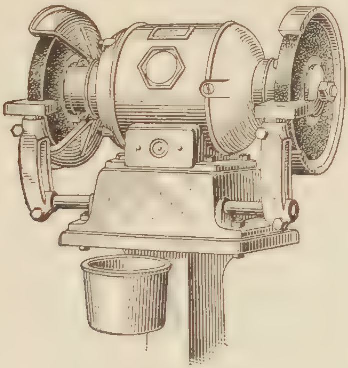


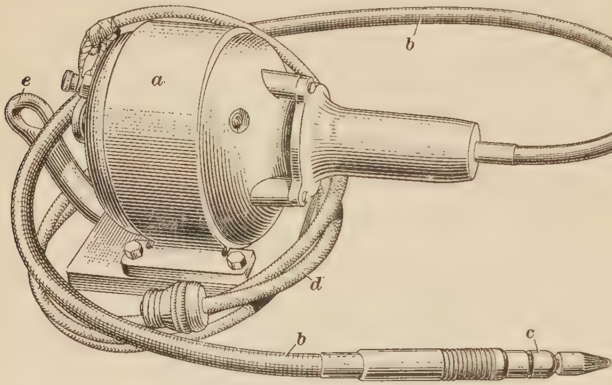
FIG. 18

further equipped with two adjustable tool rests, safety wheel guards, a starting switch in the base, and a water pot.

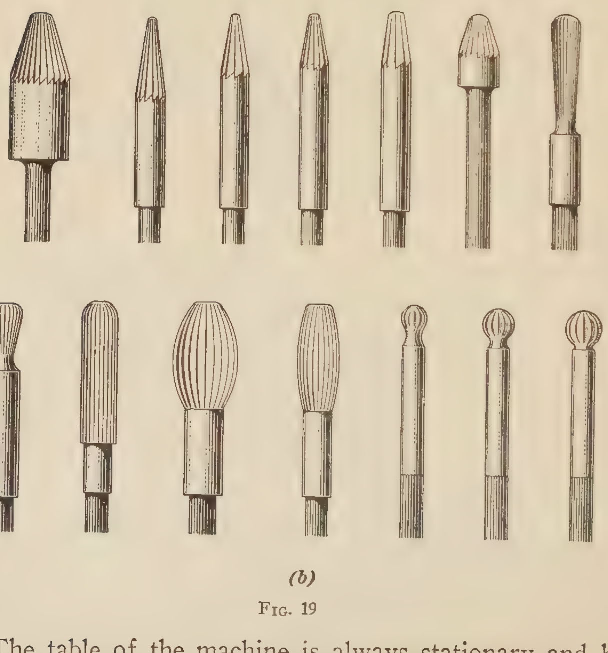
37. The flexible-shaft machine shown in Fig. 19 (*a*) may be used for a variety of purposes in making metal patterns. It consists of a small electric motor *a* which drives a flexible shaft in the shield *b*. The tools are held in the hand chuck *c*, and the electric cable *d* may be attached to the power circuit. An eyebar *e* is used to hang the motor in any convenient location near the work. The motor can also be set on a bench. A set of tools like those shown in view (*b*), together with various grinding wheels may be used in the hand chuck of this machine.

38. A circular saw machine, as shown in Fig. 20, is used for cutting sheet white metal and sheet brass, and for slotting

metal patterns and core boxes. The automatic shield *a* covers the saw, which is driven by an electric motor *b* through gear-



(a)



(b)

Fig. 19

ing. The table of the machine is always stationary and horizontal, but the saw and motor may be raised by means of the

hand wheel *c*, or tilted by means of a hand wheel on the shaft *d*. The angle of tilt, which may be as great as 45°, is shown on the graduated scale *e*. The saw is usually 8 inches in diameter and $\frac{3}{32}$ inch thick. A circular saw works best when about one-

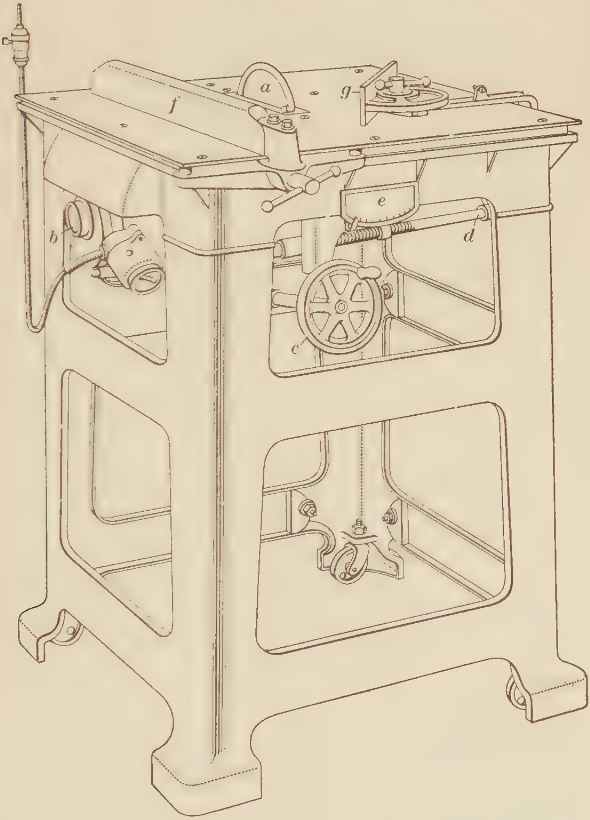


FIG. 20

third of its diameter is above the table. Two fences *f* and *g* are used on the table. Each of these may be set at any angle, and each is held by a quick-acting clamp.

A shearing machine capable of cutting all internal and external shapes in sheet metals up to $\frac{1}{4}$ inch thick and at a rapid rate is very useful in the larger shops.

39. Bench Plate.—A surface, or bench, plate is used for laying out patterns and core boxes and for testing the accuracy of flat surfaces. The type of bench plate commonly used, shown in Fig. 21 (*a*), is made of cast iron and has the face *a* ground true.

40. Angle Irons.—Angle irons are used for laying out metal patterns and core boxes on a bench plate. Two common sizes of angle irons used are 6×8 inches and 12×14 inches, the dimensions representing the width and height of a cross-section of the angle iron. One form of angle iron is shown in Fig. 21 (*b*). The vertical slots are used to clamp patterns on

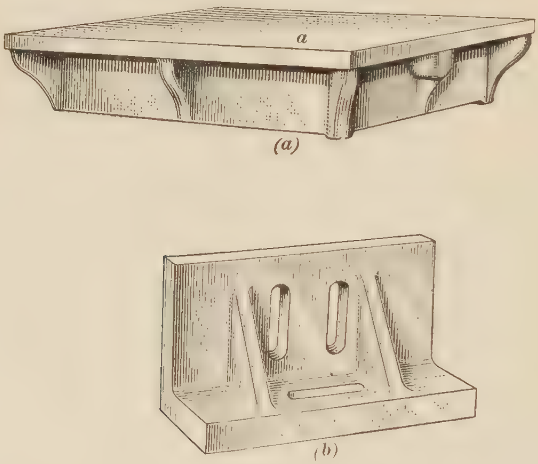


FIG. 21

the angle iron during the laying-out process. The slot in the base is for the bolt that fastens the angle to the machine table.

41. Parallels.—Hardened and ground steel blocks, or parallels, are used on the patternmaker's bench in laying-out and gating metal patterns. They vary in cross-section from $\frac{5}{16}$ inch×$\frac{1}{4}$ inch to 2 inches×1 inch, and in lengths from 5 inches to 12 inches.

42. Drills, Reamers, Taps and Dies.—Twist drills up to 1 inch in diameter are generally of the straight-shank type,

while those over 1 inch in diameter have a tapered shank. Straight reamers up to $1\frac{1}{2}$ inches in diameter are either of the solid or the expansion type. Tapered reamers having either $\frac{1}{4}$-inch or $\frac{1}{2}$-inch taper per foot are used to produce the necessary draft on the sides of holes in metal patterns and core boxes. Reamers used in metal-pattern making usually have spiral flutes, except in the case of expansion reamers, which have straight flutes. Standard taps and dies are used for threading metal patterns and the studs and bolts used in making the patterns.

43. The sizes of machine screws and their tap drills used in making metal patterns are either referred to in inches of diameter or by numbers. Table I shows the relation between

TABLE I

NUMBERS AND SIZES OF MACHINE SCREWS, TAPS, AND TAP DRILLS

No. of Screw and Tap	No. of Threads per Inch	Tap Diameter Inch	Tap Drill	
			Diam., in Inches	Number
18	18	.2959	.2280	1
16	20	.2698	.2055	5
15	18	.2560	.1935	10
14	24	.2438	.1960	9
14	20	.2438	.1850	13
12	28	.2176	.1800	15
12	24	.2176	.1730	17
10	32	.1916	.1590	21
10	30	.1916	.1610	20
8	32	.1655	.1360	29
8	30	.1655	.1285	30

the number of machine screw, the number of threads per inch, the diameter of tap, and the diameter and number of tap drill for the machine screws most commonly used. In most cases a slight variation in the tap diameter is permissible, depending on whether a tight or loose screw fit is desired.

44. Clamps.—Steel clamps, one form of which is shown in Fig. 22, are used to hold metal patterns on angle irons or

surface plates, and to clamp the two halves of a pattern or core box together during machining operations. The sizes commonly used have 4, 6, 10, and 14 inches maximum openings.

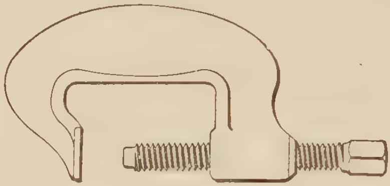
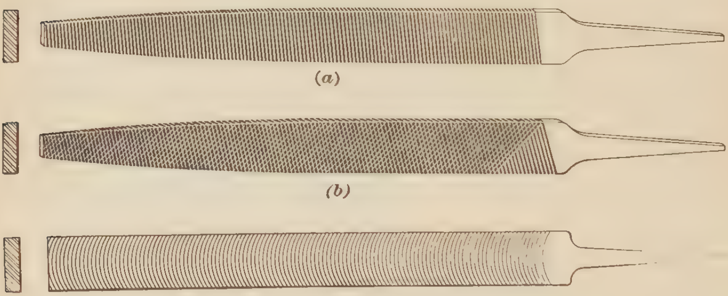


FIG. 22

45. Files, Scrapers, and Chisels.—Metal patterns and core boxes are usually finished by filing or scraping to size. The files most used for metal-pattern making are the tapered single-cut shown in Fig. 23 (*a*), the tapered double-cut shown in (*b*), and the circular cut shown in (*c*). The circular-cut files are adapted to the cutting of white metals, aluminum, solders, etc. This form permits the chips to fall at the end of the cut and thus prevents clogging. The following sizes are used on brass and cast iron: 6-, 8-, and 10-inch flat bastard, half-round bastard,



(*a*)

(*b*)

(*c*)

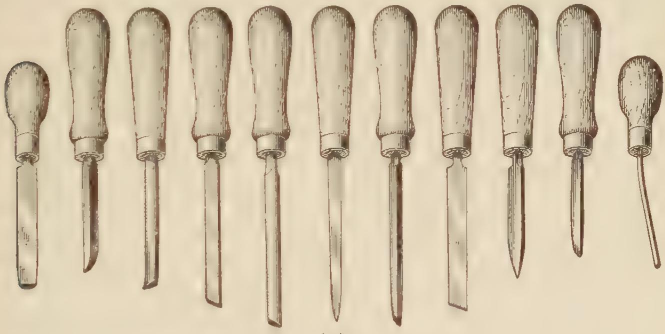
FIG. 23

flat mill, and half-round mill files; 6-inch and 10-inch round bastard and round mill files.

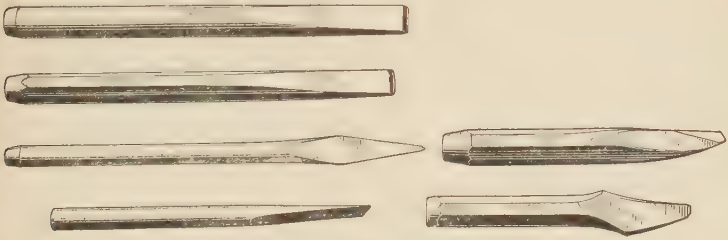
46. Scrapers of various shapes and sizes, used for finishing metal patterns and core boxes to size, are made of tool steel or worn files, forged and ground to shape. A set of scrapers commonly used on metal patterns is shown in Fig. 24 (*a*).

Chisels are used to chip off excess metal and are either flat or round-nosed, as shown in view (*b*). A chisel for aluminum or white metal should be sharpened on one side of the point only, while chisels for cast iron are sharpened on both sides of the point.

47. Precision Tools Used in Making Metal Patterns.—The precision tools used in making metal patterns include depth gauges, surface gauges, calipers, micrometers, dividers, trammels, etc.



(*a*)



(*b*)

Fig. 2.

A 6-inch depth gauge is used for measuring the depth of blind holes and shallow recesses in patterns and core boxes, and for checking the height of core prints and lugs. This tool measures the depth of a hole by means of a scale, which is forced against the bottom of the hole when a spring in the barrel of the instrument is released. By turning a locking nut at the top of the barrel, the scale is locked in position so that it can be read after the gauge is withdrawn from the hole.

48. A surface gauge is used to check the height of a metal pattern or core box placed on a surface plate, or to scribe lines on the pattern parallel to a side or surface plate. One-inch and two-inch micrometers are used on interchangeable patterns when it is desired to check dimensions to one-thousandth of an inch. For checking outside dimensions that do not require such a degree of exactness, outside spring calipers are used, while inside spring calipers are used for measuring the diameter of holes and recesses in patterns and core boxes, and for transfering measurements from the pattern to the core box. A caliper square is a convenient instrument for accurately checking the draft of thin partitions, and for checking interchangeable patterns.

49. Spring dividers are used to scribe circles and for general layout work. A drill and wire gauge is used to find the drill or wire size to make a drive fit for pins and rivets. The gauge also gives the correct size of drills for holes that are to be tapped. Steel-beam trammels are used for scribing large circles or arcs in laying out patterns and core boxes. By using special caliper attachments in place of the divider points, the trammels can also be used for calipering both inside and outside dimensions of large patterns and core boxes. In addition to the instruments described, a number of other layout tools, such as bevel protractors for laying out and transfering angles, centering tools, thread gauges, etc., are used in making metal patterns.

50. Shrink Rules for Metal Patterns.—To compensate for the shrinkage of the metal in making a casting from a metal or wooden master pattern, a shrink rule is used in building the master pattern. Since there is also a shrinkage of the metal of the iron casting made from the metal working pattern, the master pattern must be made with an extra shrinkage allowance to take care of this second shrinkage; in other words, the master pattern is said to be built with *double shrink*. The rule generally used in making such a pattern is a 24-inch scale having a shrinkage allowance of $\frac{1}{8}$ inch per foot for the iron casting and $\frac{3}{16}$ inch per foot for the brass or malleable-iron working pat-

tern. If a brass casting is to be made from a brass working pattern, the master pattern is made with a double shrink of $\frac{3}{8}$ inch per foot, and if an aluminum casting is to be made from an aluminum working pattern, the master pattern is made with a double shrink of $\frac{5}{16}$ inch per foot.

51. Marking of Metal Patterns.—Letters and figures, of the Roman type, as in Fig. 25 (*a*), are placed on metal patterns

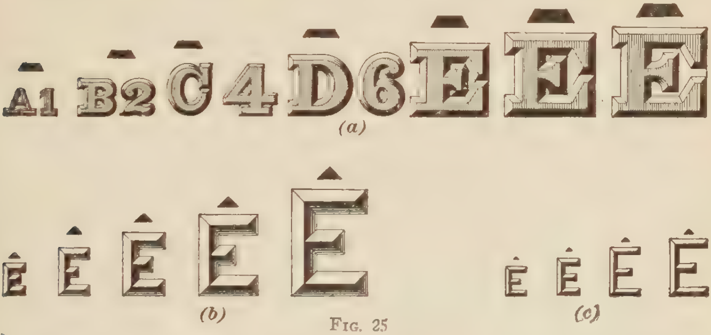


FIG. 25

for the purpose of identifying castings and to advertise the manufacturer's name or goods. The black forms above the letters show their thickness. Cast brass and white-metal letters and figures of the sharp gothic type, view (*b*), and the hairline type (*c*), are also used for this purpose. Finished cast letters and figures in various sizes and thicknesses are on the market. The surface of the pattern on which the letters are to be placed is first tinned, after which the letters are placed in position and soldered on by heating the surface with a blow torch.

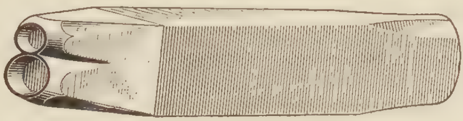


FIG. 26

When a raised letter or figure on a pattern is undesirable, the identification mark may be stamped on the pattern by the use of a steel stamp such as shown for the figure **8** in Fig. 26. The sides of the letters and figures on the stamp have plenty of

draft, so that their impressions on the patterns will draw freely from the sand. The butt of the stamp is given a few light blows to produce the indentation, care being taken to strike each stamp used with about the same force. The metal around the indentation becomes slightly raised and is filed flush with the surface of the pattern, after which the letter is brushed with a stiff wire brush to remove the sharp edge produced by the file.

METAL-PATTERN CONSTRUCTION

ELEMENTARY PRACTICE

52. Master Pattern Construction.—When a pattern is thin and of uniform thickness, such as the pattern shown in Fig. 27, the master pattern is built up of sheet brass, as a wooden master pattern would warp badly and would be too expensive. In building the master pattern, it is important to ascertain first how and for what purpose the casting is to be used, in order to determine the degree of finish required on the various parts, and what dimensions of the master pattern must be held to the closest limits. In the casting shown in Fig. 27 which represents a cover for an electric refrigerator control unit, the box part fastened in front of the flat back plate *a* is to contain the electric starting unit, which is operated by a push button in the hole of the front cover plate *b*. The dimensions of the box part of the master pattern should therefore be held to very close limits. All other dimensions may vary by $\frac{1}{64}$ inch from the values given on the working drawing. As a general rule, the dimensions of any master pattern, as measured with the shrink rule, should conform as closely as possible with the dimensions given on the drawing.

53. As the thickness of the casting, Fig. 27, is $\frac{1}{8}$ inch, a piece of sheet brass $\frac{1}{8}$ inch thick, 8 inches wide and 14 inches long is used for laying out the back plate *a*, the front cover plate *b*, the top cover plate *c*, and two side cover plates *d*. The layout is shown in Fig. 28 (*a*). It will be noted that the bottom plate *e*, view (*b*), of the casting is not included in this layout for reasons that will be explained later. In order to file the proper taper, or draft, on the edges of the parts that have been laid

out, the manner of drawing the master pattern from the sand must first be considered. The draft of $\frac{1}{32}$ inch on the side and top plates of the cover as indicated in the end view and the plan of Fig. 27, determine the line xx as the proper parting

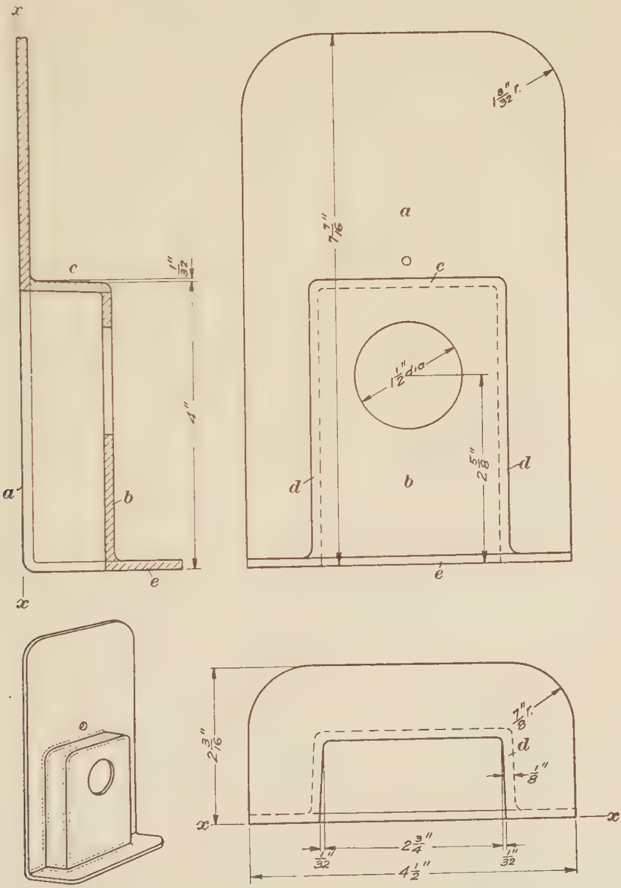


FIG. 27

line, the parts above the parting line being molded in the drag, as shown in the plan view. In cases where no natural draft from the parting line is shown on edges of parts on the drawing, it is customary to allow a taper of .05 inch per inch in the construction of the pattern.

54. The layout of the parts of the master pattern as described in the preceding article is shown in Fig. 28. This layout is drawn according to the dimensions shown in Fig. 27, but the measurements on the layout are made with a $\frac{3}{8}$ inch per foot shrink rule. This takes into account the $\frac{3}{16}$ inch per foot shrink of the brass pattern cast from the master pattern, and also the $\frac{3}{16}$ inch per foot shrink of the final brass casting made off the metal working pattern. Each part is then sawed out along the lines laid out, an allowance of $\frac{1}{64}$ inch of metal being made for finishing with a mill file. The bottom plate *e* of the pattern shown in Fig. 27 requires good draft and is made from $\frac{5}{32}$-inch sheet brass and a taper, or draft, of $\frac{1}{64}$ inch is filed on each side, as shown in the section, Fig. 28 (*c*), taken along the line *fg*, view (*b*).

55. Master-Pattern Assembly.—All the parts of the master pattern may now be assembled and fastened together to make the complete pattern. The plates marked *d* on the layout in Fig. 28 form the two side plates of the cover. The back plate *a*, Figs. 27 and 28, is first straightened on a surface plate, after which the bottom plate *e* is soldered lightly to it at right angles. The side plates *d* of the box cover are next soldered in place, being lined up by the sides of the opening in the bottom plate *e*. This will produce the $\frac{1}{32}$-inch draft on the side plates. The top and front cover plates *c* and *b* are then soldered on, after which all the joints are sweated together at one or two places. It is not necessary to solder along the whole joint, the object being to hold the master pattern together long enough to make the few castings for the required metal patterns. Sweating is done by holding the soldering copper on the joint until the solder sweats through on the opposite side. The fillets are put in with wax filler, and smoothed to the correct radius with a round-end fillet tool. The outside corner surfaces are filed to a curve of as large radius as the material at the corners will permit.

56. Next, the whole master pattern is sandpapered with No. 00 sandpaper. As an aid to the molder in drawing the pattern from the sand, the lines and scratches made by the

abrasive should run in the same direction as that in which the pattern will be drawn from the mold. The parting line is shown at *xx* in Fig. 27. A hole *h*, Fig. 28 (*a*), is drilled with a No. 12 drill for insertion of a small sharpened wooden stick which is used to draw the pattern.

Other types of master patterns are machined out of solid metal. Escutcheons, covers, and similar thin flat master pat-

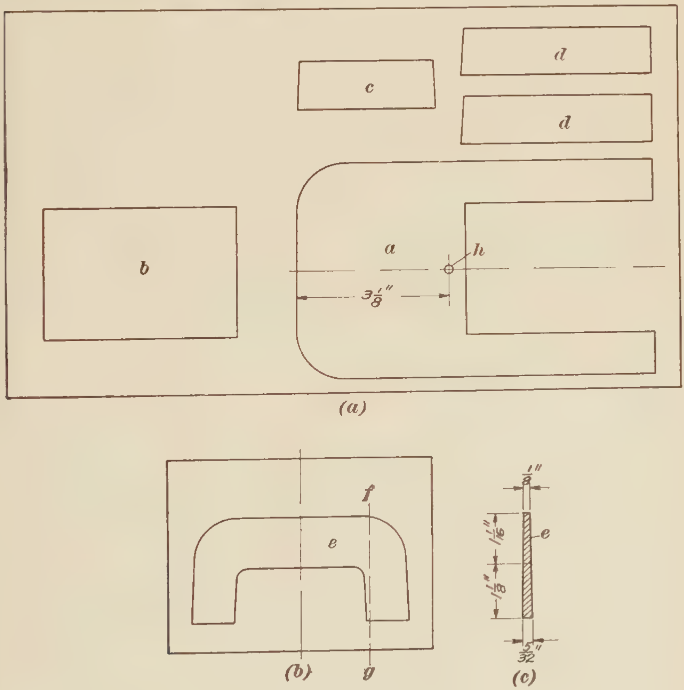


Fig. 28

terns are made from solid metal by milling out the recesses and filing to size. The master patterns of handles, pipe fittings, and cylindrical master patterns are turned in a lathe and the flat portions machined in a miller or shaper.

57. Construction of Sheet-Brass Working Pattern.—The form of some castings is such that a sheet-brass working pattern can be made without a master pattern. An example of

such a casting is shown in Fig. 29 (*a*). The casting is a resistance grid and consists of a number of bars *a* joined together. The thickness of the casting is uniform and is ¼ inch with the exception of the end lugs *b* which are ½ inch thick. Two identical sheet-brass patterns are made and are mounted on the same pattern plate.

To make the pattern, the grid is laid out on a piece of sheet brass ¼ inch thick, without the end lugs. The layout is simply

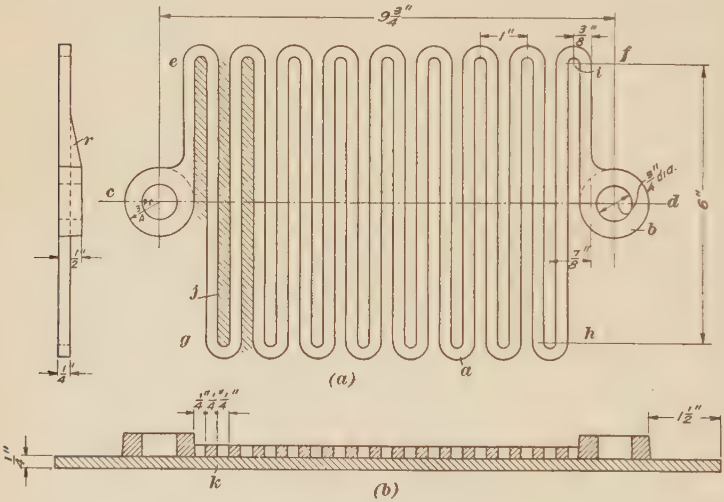


FIG. 29

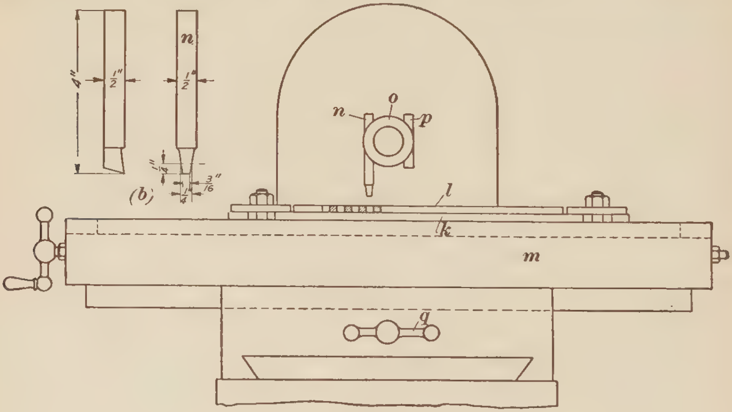
a copy of the drawing scribed on the sheet brass. First, the center line *cd* is scribed with a steel scriber, and then two lines *ef* and *gh* are drawn parallel to the center line, each at a distance of 3 inches from it. These lines contain the centers for the semicircles at the ends of the grid loops. After locating the first of these centers *i* on the upper parallel line, at a distance of ⅜ inch from the right-hand edge of the sheet brass, the other centers may be prick-punched 1 inch apart. Nine centers are marked on the line *ef*. The process is repeated for the centers on the line *gh*, eight centers being marked off starting with the first center ⅞ inch from the right-hand edge of the sheet brass. Semicircles are then drawn around each of the centers with radii of ⅛ inch and ⅜ inch, and the upper and lower semicircles

are then joined by lines to form the grid bars. All the measurements are made with a $\frac{1}{8}$-inch per foot shrink rule. To avoid confusion as to which part is to be cut away in the machining of the pattern, the spaces *j* between the bars are plainly marked with chalk, or similar means.

58. The layout plate is next straightened on a surface plate by means of a rawhide mallet, and soldered to a plate of sheet brass *k*, Fig. 29 (*b*), $\frac{1}{4}$ inch thick having a margin of $1\frac{1}{2}$ inches all around the plate, as shown in view (*b*). The soldering is best done by first tinning the sheet brass which is accomplished by covering one side of it with solder. The solder is wiped off with a brush while still hot, to remove any excess solder and leave only a thin smooth layer of solder on the plate. The sheet brass must next be straightened as it will have warped due to the heat from the tinning process. The layout plate and the sheet brass are then clamped together and heated in order to sweat them together by running solder between the joints.

59. When the plates have cooled, a No. 12 gauge drill is used to drill holes in the ends of the spaces between the grid bars, the drill being placed in each of the prick-punched centers *i*, after which a taper reamer having a taper of $\frac{1}{4}$ inch per foot is run down into each of the holes to finish them to the correct size and furnish the proper draft to the sides of the holes. The work is next set up in a milling machine in order to cut away the spaces between the grid bars. In Fig. 30 (*a*) the work *l* is shown clamped to the milling machine table *m*, and the forged cutting tool *n* is shown in detail in view (*b*). The width of the cutting edge of the tool is made equal to the width of the space between two grid bars, and the tool is mounted on the milling machine spindle between two spacing washers *o*, view (*a*), which bear against the tool and against a piece of steel *p* having the same thickness as the tool shank. The spindle is locked in place by throwing in the back gears of the milling machine. If the gears are old and worn a small brass wedge is placed between the teeth to take up the backlash and prevent the gears from moving.

60. The work is lined up on the milling machine table *m*, Fig. 30 (*a*), with the grid bars at right angles to the edge of the table, and the table is raised so that the cutting tool will cut to a depth of $\frac{1}{32}$ inch, the cut being made by moving the table crosswise by means of the cross-screw handle *q*. The table travel is so adjusted that the tool will cut the entire length of the slot. As each cut removes $\frac{1}{32}$ inch from the metal, it takes eight cuts to finish one slot, the thickness of the metal of the layout plate being $\frac{1}{4}$ inch. The tool must be kept very sharp so as to cut the sides of the slot smooth. The cutting point of the



(*a*)
FIG. 30

tool is ground with $\frac{1}{32}$-inch taper on each side to produce the necessary draft on the edges of the slots. After the first slot is cut, the table is moved lengthwise to bring the next slot in line with the cutting tool. In this way all the slots between the grid bars are cut. The work is then removed from the milling machine table and heated over a gas flame until the grid is loosened from the supporting sheet brass plate *k* by the melting of the solder. A strip of sheet brass $\frac{1}{16}$ inch thick and $\frac{3}{4}$ inch wide is soldered across the top of the grid along the center line *cd*, Fig. 29 (*a*), to keep the grid from stretching out of shape during the finishing operations. All burrs and sharp edges are removed by filing, and the grid is straightened by a slight pressure of the hand.

61. The lugs *b*, Fig. 29 (*a*), at the ends of the grid are made separately, from a piece of sheet brass $\frac{9}{16}$ inch thick which is milled down to a thickness of $\frac{1}{2}$ inch, as measured by a $\frac{1}{8}$-inch per foot shrink rule. Two rings are turned from this piece, each having an outside diameter of $1\frac{1}{2}$ inches and a hole $\frac{3}{4}$ inch in diameter in the center. The sides of the rings are given $\frac{1}{32}$ inch draft. The lugs are next soldered to the grid by placing the grid and lugs on a surface plate with a thin sheet of paper underneath so that the soldering acid will not injure the surface plate. Before applying the solder the lugs are carefully located with respect to the ends of the grid by referring to the drawing of the casting. The sloping surface *r* shown in the end view of Fig. 29 is carefully built up with solder, after which the reinforcing brass strip which was soldered across the center of the grid is removed by melting the solder at the junctions with the grid bars. All surplus solder is then removed with a file and the rough spots on the pattern are smoothed with sandpaper. Extreme care must be taken in filing and sandpapering the sides of the slots and of the pattern, so as to avoid forming an opposite, or back, draft which may cause the sand to stick to the pattern when it is drawn from the mold. The same harmful result is produced when the bottom of the sides of the slots are rounded, and care must be taken to prevent this.

62. Mounting Sheet-Metal Pattern.—The pattern is now ready to be mounted on the pattern plate which is done by driving No. 30 copper rivets through each bar at the center and ends, and through the pattern plate. Rivets are also driven through the end lugs. The pattern plate is made of sheet steel $\frac{1}{4}$ inch thick. In molding the casting the drag half of the flask is placed on the side of the pattern plate containing the patterns, and the cope is placed on the opposite side. Two or more identical patterns may be mounted on the same pattern plate so as to increase the production of castings.

The brass pattern of the grid could also be made by cutting a number of grid bars on a shaper or milling machine, cutting a number of brass washers in halves, and brazing together the bars and the washers so cut. This method of making the pat-

tern is expensive, because of the time required in making and brazing the parts, and in removing the excess metal at the brazed joints. A shaper may also be used instead of a milling machine to cut the slots between the grid bars, as in the process just described, but, unless the shaper is in excellent condition,

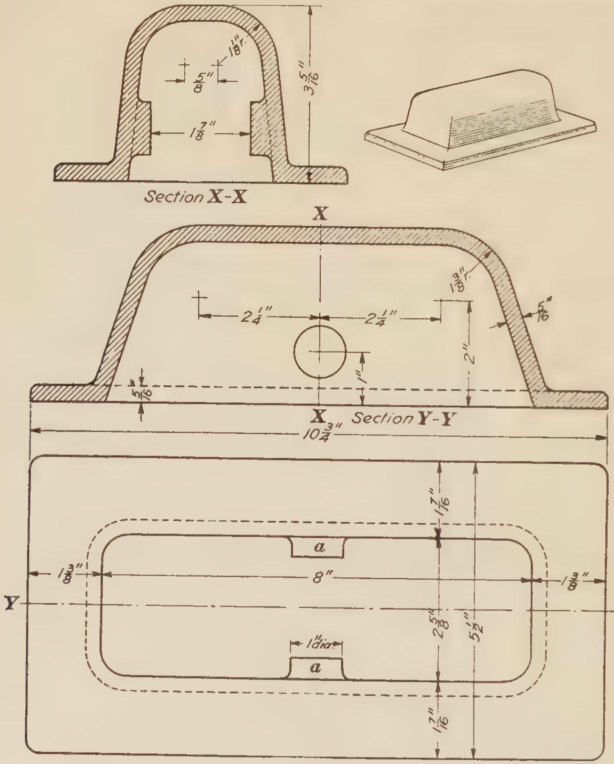


FIG. 31

the shaper tool will not produce a straight cut, or the travel of the tool may exceed the required length of stroke and spoil the pattern. The milling process is slower, but the results obtained are generally much better than those from a shaping process.

63. Construction of Plaster Master Pattern of Gear Case. Suppose that a white-metal pattern must be made for the cast-iron gear case shown in Fig. 31. If the number of castings

to be made of this pattern is not very large, a shell master pattern made of wood would be too expensive. In this case the master pattern may be made of plaster of Paris. From a study of the drawing, it will be seen that the general thickness of the casting is $\frac{5}{16}$ inch, and that it is important to have the bosses *a* on the inside of the casting in the correct location. The general method of making a plaster master pattern is to shape a piece of wood the same as the inside of the gear case and cover it with a layer of modeler's clay to the thickness of the casting. A mold is then made of the block and clay, after which the clay is removed from the block and the mold closed and poured

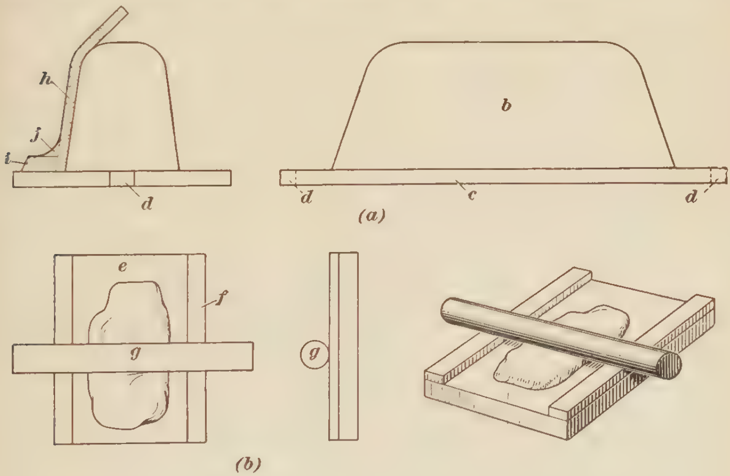


FIG. 32

with plaster, which fills the space left by removing the clay, thus forming the shell master pattern. A detailed description of the process of making a plaster master pattern of the gear case shown in Fig. 31 is given in the following articles.

64. A pine block *b*, Fig. 32, is first shaped to the inside dimensions of the casting, Fig. 31, using a rule having a double shrink of $\frac{1}{8}$ inch per foot for the iron castings made from the white-metal pattern, and $\frac{3}{64}$ inch per foot for the white-metal pattern made from the plaster master pattern. The block of wood is made without the shaft bosses *a*, the surface being per-

fectly smooth as shown at *b* in Fig. 32 (*a*). It is then painted with two coats of thin yellow shellac to keep out the moisture and produce a smooth surface, after which it is fastened with wood screws to a flat board *c* that extends about 4 inches all around the block. The board *c* has **V** slots *d* cut at each end, to fit the pins of the drag half of a snap flask. The clay is now prepared in the following manner.

65. A small surface plate *e*, Fig. 32 (*b*), is provided with two removable steel parallel edges *f* the thickness of which is $\frac{11}{32}$ inch. The clay is placed on the surface plate and rolled out to the thickness of the parallel edges *f* with a rolling pin *g*. The clay should be just wet enough to prevent it from sticking to the plate. After the clay has been rolled to an even thickness of $\frac{11}{32}$ inch, it is cut into strips about 4 inches wide and 6 inches long which are placed on the pine block, as shown at *h*, view (*a*), until the block is completely covered. The clay must be handled carefully so as to preserve the correct thickness of the layer. The flanges of the gear case are made of strips of clay *i*, $\frac{3}{8}$ inch thick, which are rolled out on the face plate *e*, view (*b*), after the $\frac{11}{32}$-inch steel parallel edges *f* have been replaced by $\frac{3}{8}$ inch parallels. The added thickness of the flanges is necessary to provide for a finishing grinding operation which removes $\frac{1}{32}$ inch from the face of the casting. A draft of $\frac{1}{32}$ inch is cut on the outside edge of the clay strips that form the flanges.

66. The fillets *j*, Fig. 32 (*a*), are next formed by pressing a triangular strip of clay in place with a short piece of wood dowel of $\frac{1}{2}$-inch diameter, which has been sandpapered smooth. After the clay on the block has been heated with a blow torch until it begins to steam, fine molding sand is rubbed in with the hands. The moisture of the steaming clay causes the sand to stick to the surface, the object being to prepare the clay surface so that it will not stick to the molding sand when it is drawn from the mold. When the clay has acquired a thin coating of sand, it is allowed to cool and dry for about one-half hour. Care must be taken not to dry the clay completely, which might cause it to raise and move away from the block. The

clay is then covered with a parting compound, which is dusted on by shaking a cloth bag containing the compound over it.

67. The pattern formed by the wood block with the clay covering is used to make a mold. First, the drag half of a flask is placed over the pattern and rests on the board *c*, Fig. 32 (*a*), with the flask pins in the **V**'s *d* of the board. The flask is rammed full of sand in the usual way, and a 3-inch diameter sprue pattern about 10 inches high is placed on top of the clay surface and in the center. The sand must be carefully rammed so as not to crush the clay. The flask is then lifted off the pattern and the clay removed from the pine block, after which the block is coated with a thin layer of grease and the flask again placed over the block. Plaster is poured into the mold and when set, the flask and sand are removed, and the sprue sawed off the pattern. The screws that hold the board *c* to the pine block *b* may now be removed and the board withdrawn. The block is then drawn from the plaster shell covering by inserting a large woodscrew in the wood and rapping it lightly with a hammer. Sometimes it is necessary to heat the plaster in order to melt the grease on the block before the plaster cover can be freed. The outside surface of the plaster shell is then trimmed down with a sharp knife where necessary, and the thin places built up with plastic plaster, which is allowed to set and then trimmed to the correct dimensions. Finally, the plaster shell is sandpapered with No. 0 sandpaper and a draw-hole drilled through the center of the top of the shell with a No. 12 drill. In order that the shell may be drawn freely from the sand, it is painted with two coats of very thin yellow shellac, which produces an excellent smooth surface.

68. Construction of White-Metal Working Pattern of Gear Case.—A white-metal working pattern is made from the plaster master pattern of the gear case shown in Fig. 31. The plaster pattern is bedded firmly in a match or temporary cope, while the drag is being made. This is done so as not to break the plaster pattern. The ramming of both halves of the mold must be done carefully. If it is rammed too hard, the plaster is usually broken, and if not rammed hard enough the inside

of the white-metal casting will have raised parts which must be removed either by scraping or by the use of a flexible-shaft grinder or miller, similar to the one shown in Fig. 19. When the pattern has been reduced to size it is sandpapered all over to a smooth finish.

69. The bosses *a*, Fig. 31, are made loose in the pattern so that they can be drawn from the sand after the pattern has been removed. This is done as follows: First, a $\frac{1}{16}$-inch deep dovetail recess is chipped out on each side of the inside of the

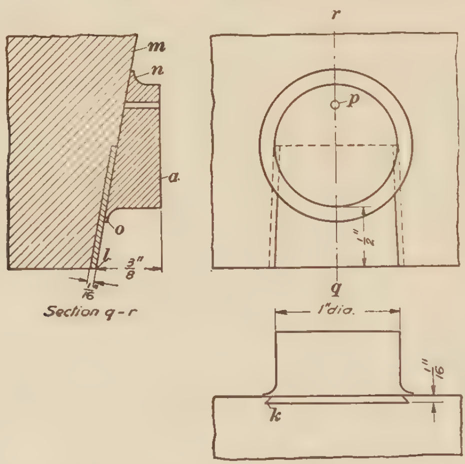


FIG. 33

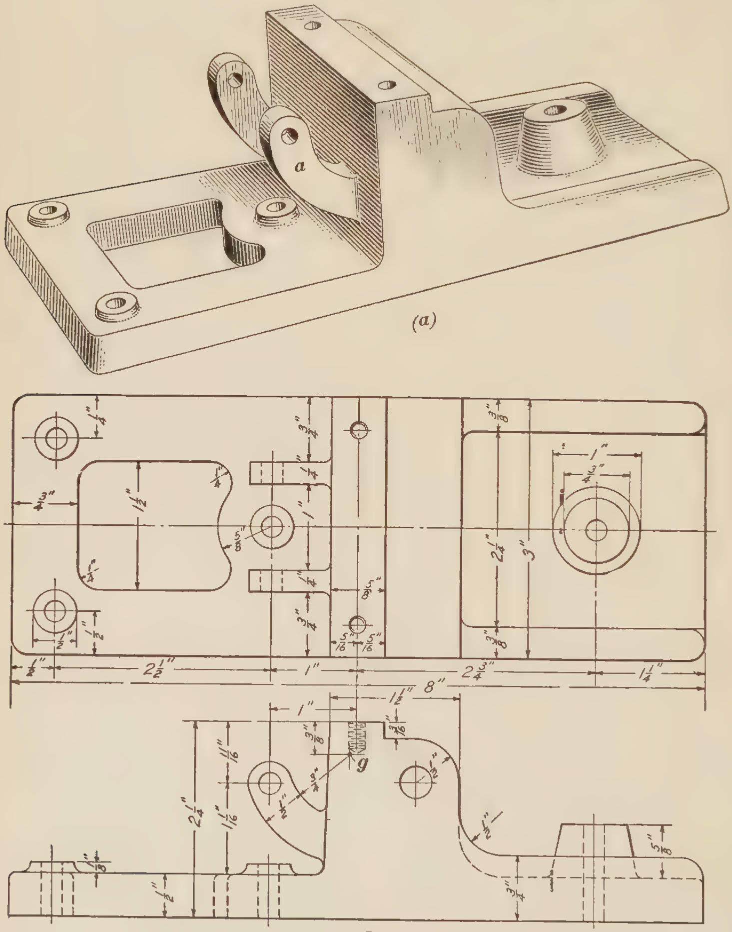
pattern as shown at *k*, Fig. 33. The recess is first cut out in the form of a slot $\frac{1}{16}$ inch deep, and the undercut in the dovetail is then scraped out with a sharp-pointed scraper. Two pieces of sheet brass *l*, $\frac{1}{16}$ inch thick are filed to fit the dovetail recess in such a way that the surface of the sheet brass is flush with the inside surface *m* of the pattern, and that they can be easily removed from the pattern. Next, the bosses *a* are turned up separately in a lathe from two pieces of sheet brass $\frac{3}{8}$ inch thick and about $1\frac{1}{4}$ inches square. Each piece is soldered to a short length of $\frac{1}{2}$-inch brass rod which is held in a chuck of the lathe while the boss is being turned. The sloping back is then formed on each boss by filing to the dimensions given on the

drawing, after which the fillets n are built up of solder. Care must be taken to leave an edge o about $\frac{1}{32}$ inch thick on the bosses to prevent the fillets from being bent over or upset. The bosses may then be loosened from the brass rods by heating them with a torch.

70. The brass dovetail pieces l, Fig. 33, are next placed in the recesses k in the pattern and the bosses soldered onto them after being lined up on the face of the pattern by use of a surface gauge. The proper location of the centers of the bosses is marked with a prick-punch and the bosses and dovetail pieces removed from the pattern. The bosses are then permanently fastened to the dovetail pieces by two No. 30 gauge brass rivets. A hole p is drilled near the top of the bosses with a No. 30 drill to serve as draw hole. It is better to drill this hole near the top than near the bottom, for if it is near the top the boss and the dovetail piece may swing on the draw hook and spoil the surface of the mold. It is very important that the dovetail pieces slide easily in the pattern recesses, as otherwise it is very difficult to draw the pattern from the mold without disturbing the bosses. Proper identification marks are stamped on the backs of the dovetail pieces so that they can be restored to their proper recess in case they should become separated from the pattern.

71. Pattern With Draw-Back.—Some castings have projections that prevent their patterns from drawing readily from the mold. In such cases the projections may be made as loose pieces on the pattern, and these are drawn separately after the body of the pattern has been taken from the sand. In cases where the pattern body has sufficient volume, it is possible to draw the loose pieces back into the hollow body and to lift the entire pattern together from the mold. An example of the draw-back type of pattern is that used for molding the iron casting shown in Fig. 34, in which (a) is a general view of the casting and (b) is a copy of its blueprint. The pattern work for this casting consists of a master pattern and a core box both made of wood, and an aluminum working pattern having draw-backs for the lugs a.

72. Master Pattern For Draw-Back Example.—The wooden master pattern is made with a double shrink of $\frac{5}{32}$ inch per foot for the aluminum working pattern, and $\frac{1}{8}$ inch per foot



(b)
Fig. 34

for the shrink of the iron castings. The construction of the master pattern and its core box is shown in Fig. 35. Two pads *b*, view (*a*), are built on the pattern where the lugs are to be located. These pads are $\frac{1}{16}$ inch wider and higher than the

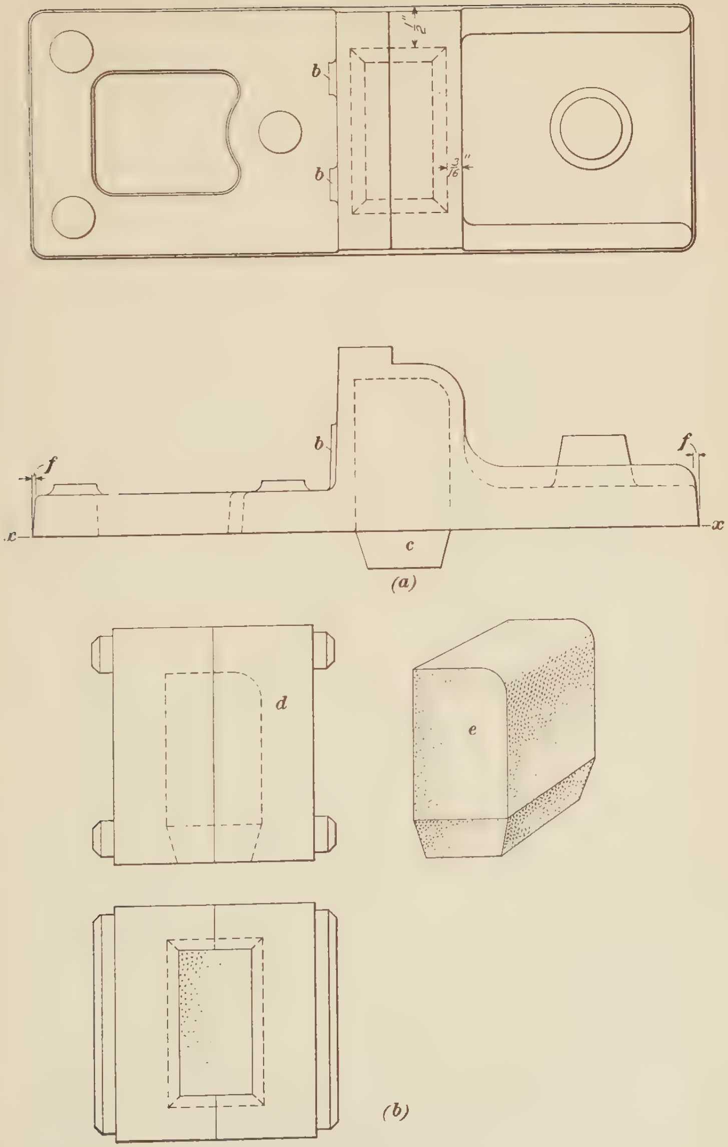


Fig. 35

base of the lugs and extend clear down to the top surface of the bottom plate so that they will draw from the sand as a part of the body pattern. A rectangular core print *c* is required for the core used to form the cavity in the working pattern. The two-part core box *d*, view (*b*), is used to make the core *e* that molds the cavity. As only one core is needed in this example, it may be possible to make this core by cutting down some other available core. The cutting may be done with a hacksaw and the finishing by an old flat file. A draft of $\frac{1}{32}$ inch per inch should be given all vertical sides of the pattern, as at *f*, view (*a*), the parting line being along the base *xx*.

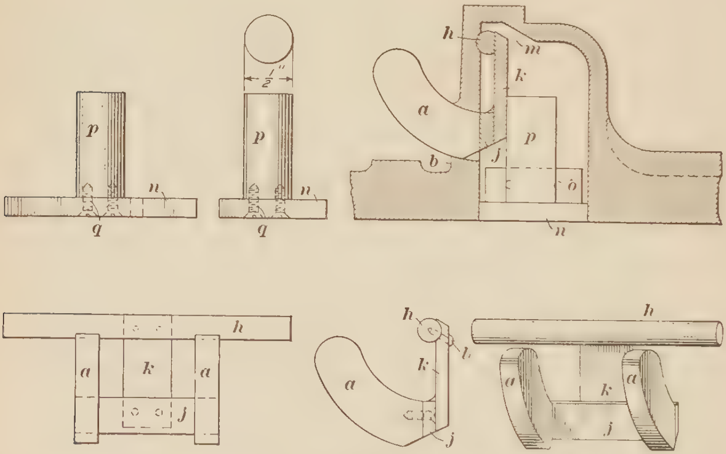


FIG. 36

73. Aluminum Working Pattern for Draw-Back Example. The body of an aluminum working pattern is molded from the wooden master pattern shown in Fig. 35 (*a*). The composition used is 8 parts by weight of aluminum and 1 part of zinc, and a partial section of this pattern is shown in Fig. 36. The metal pattern must be carefully checked. If any parts are undersize they are built up with aluminum solder, and any over-size parts are reduced by scraping or filing. The surfaces of the cored cavity are not finished except by removing any lumps that may be cast on them. The center *g*, Fig. 34 (*b*), of the arcs of the lugs is located and punch-marked on the pattern. A

$\frac{1}{4}$-inch hole is then drilled and straight-reamed through the casting, so as to make a sliding fit for a $\frac{1}{4}$-inch steel rod *h*, Fig. 36. Next, $\frac{1}{4}'' \times \frac{1}{2}''$ slots are made in the lug pads *b* by drilling a number of holes with a No. 5 drill, after which the slots are cut and finish-filed, so as to receive the curved lugs *a*.

74. Lug Patterns for Draw-Back Example.—The patterns for the lugs *a* and their mounting is shown in Fig. 36. Their patterns are cut from layouts on $\frac{1}{4}$-inch sheet brass. They must be made $\frac{3}{8}$ inch longer than the dimensions on the blueprint to allow for their extension through the slots in the wall of the pattern body. Also they are sawed out $\frac{1}{32}$ inch wider to allow for finishing by filing. A taper of about .01 inch is given for draft endwise, the outer end being the smaller one. A strip of brass *j* is used to fasten the bases of the lugs together. Besides the use of screws, as shown, the joints and screws are sweated with solder. The lugs are connected to the shaft *h* by a tie piece *k* which is riveted and sweated at each end, as shown. The arrangement is such that the whole assembly can be swung on the shaft *h*, allowing the lugs *a* to be swung into the mold outside of the pattern body, or be drawn back completely into the body.

75. Details of Draw-Back Erection.—It should be noted that the five movable parts *a, a, j, k,* and *h*, Fig. 36, must be joined together while the lugs *a, a* are in the slots and the shaft *h* in place. Therefore, it is necessary to set the lugs *a* correctly in their slots and to hold them securely by thin wooden wedges driven through the side clearance spaces through the pads *b*. All the locations and measurements must be checked carefully before making the joints. The joint on the shaft *h* is strengthened by riveting after soldering. The two rivets *l* are set at an angle because the only only way the holes can be reached is through the pattern cavity. A small angle-drill held by hand in the cavity can be used for the drilling operation. It may be necessary to chip out the cavity at the location *m* in order to give clearance for the tie piece *k*, when the lugs *a* are swung back into the body pattern.

76. Cover Plate and Stop Pin for Draw-Back.—The rectangular opening in the bottom of the aluminum pattern is covered by a plate *n*, Fig. 36, to prevent sand entering the cavity during molding service. It is made of $\frac{3}{16}$-inch sheet brass, and should fit the opening snugly and form a straight joint with the bottom, or parting, surface of the pattern. To set the cover *n* at the correct depth, two brass cleats *o*, $\frac{3}{8}$ inch square, are riveted to the surfaces inside the cavity.

In order to hold the lugs *a* in their extreme outward position while the mold is being rammed, a stop *p* is placed tightly

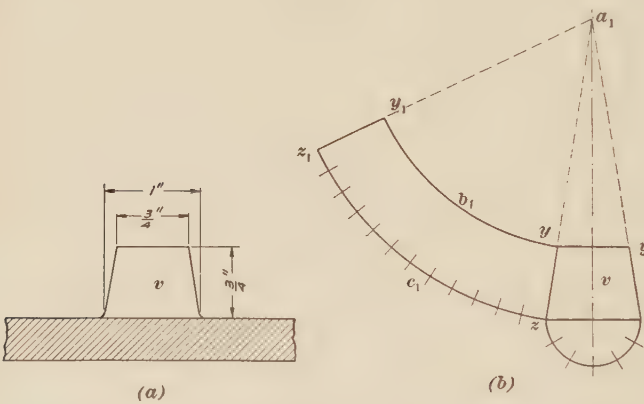


Fig. 37

against the inner surface of the tie piece *k*. The stop *p* is made of $\frac{1}{2}$-inch brass rod, which is fastened to the plate *n* by the screws *q* and by sweat-soldering. A draw hole is drilled through the plate *n*. The mold is rammed while the lugs *a* are in their outside position and the cover plate *n* in place. When the cope is lifted off, the cover *n* with the stop *p* is removed and the lugs *a* are withdrawn from the sand by placing a screwdriver behind the tie piece *k* and forcing it to swing back into the pattern cavity. After the lugs have cleared the outside surface of the pattern, the latter may be drawn from the drag.

77. Patching Aluminum Pattern.—It is sometimes necessary to enlarge the conical part of a pattern to allow for wear or to conform to changed design. As an illustration of the

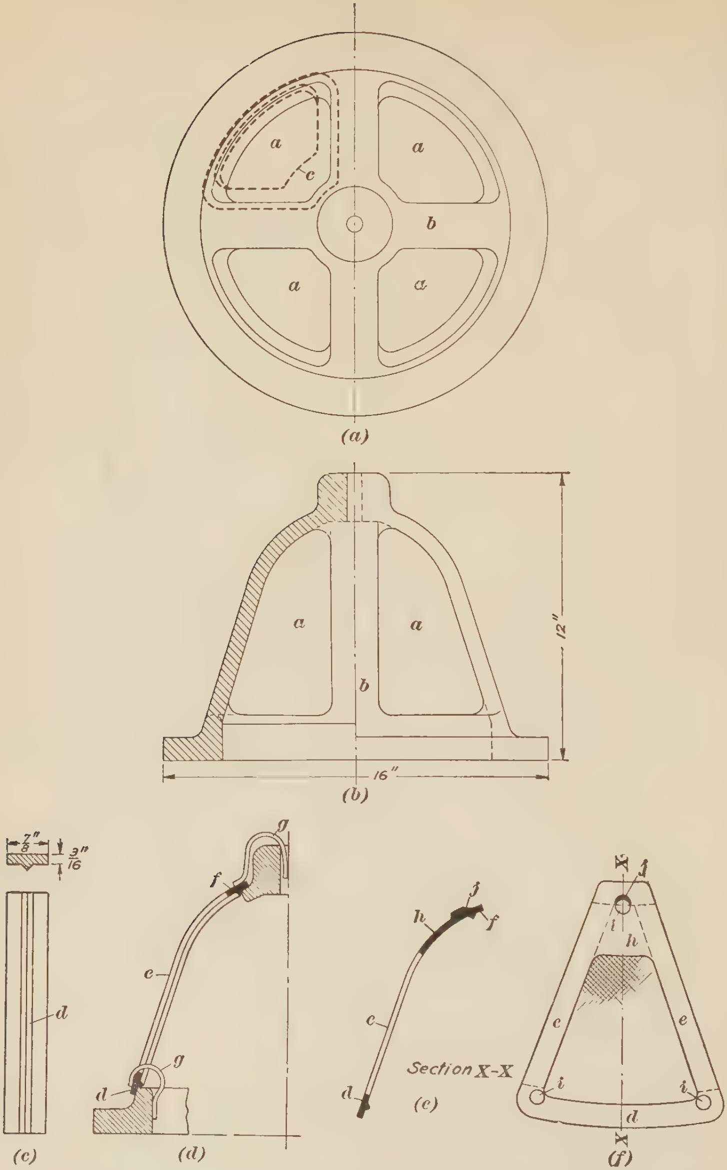
method of doing this, suppose that it is desired to increase the diameter of the boss v, Fig. 37 (a), by $\frac{1}{8}$ inch. The boss has a diameter of $\frac{3}{4}$ inch at the top and 1 inch at the bottom, and these dimensions are to be increased to $\frac{7}{8}$ inch and $1\frac{1}{8}$ inch, respectively. The enlargement is made by surrounding the sides of the boss with a strip, or patch, of sheet brass $\frac{1}{16}$ inch thick. The method of laying out the strip is shown in view (b).

The line yy is made equal to the top diameter of the boss and the line zz equal to the bottom diameter. The sides are then extended until they meet at the point a_1 of the cone. With this point as a center and with the distances a_1y and a_1z as radii, the arcs b_1 and c_1 are drawn from the left side of the boss v. A semicircle is then described on the diameter zz and divided into six equal arcs. Twelve such arcs equal to a whole circumference are then stepped off on the arc c_1. The end of the twelfth division is then connected with the point a_1, and the piece enclosed by the arcs b_1 and c_1 and the lines yz and y_1z_1 will be the correct shape of the patch required. After the patch has been sawed and filed to the lines, it is annealed by heating it to a red heat and quenching it in cold water.

The thin scale that forms on the brass during annealing must be removed by sandpapering. The patch is then wrapped around the boss and is held in place temporarily with a length of thin wire or cord, while the joint is soldered. Four small holes are then drilled through the brass into the boss and four No. 30 gauge brass rivets are used to hold the patch in place. The edges of the brass are filed flush with the top of the boss and sandpapered with No. 0 sandpaper. A small fillet of solder is built up around the base of the boss to cover the bottom edge of the patch and prevent any back draft that might be caused by the crack.

METAL PATTERN FOR IRREGULAR-SHAPED CASTING

78. Construction of Lead Master Pattern.—Let it be required to make a pattern for the brass castings of a frame for a wire screen that is placed over each of the openings a in the motor-end bearing casting b, Fig. 38 (a) and (b). The outline of the frame is shown by the dotted lines c in view (a).



a
a
c
b
a
a
(a)
a
a
b
12"
16"
(b)
7/8"
3/16"
d
(c)
g
f
e
g
d
(d)
j
h
f
c
d
Section X-X
(e)
X
h
c
e
i
i
d
X
(f)

(g)

Fig. 38

As the casting over which the frames are to fit has a very irregular shape, a working drawing of the frame from which a master pattern can be constructed is practically useless. In such cases the master pattern is made by constructing and fitting it on the casting itself, by bending some plastic material such as lead to the correct shape. A wooden pattern, as shown in view (c), is made for molding the lead strips, care being taken to cast the strips about 2 inches longer than the longest side of the opening in the end casting. The thickness of the lead strips is $\frac{3}{16}$ inch and the width $\frac{7}{8}$ inch, and each strip has a rib d along the middle of one side.

79. The strips of lead are placed along the edges of the openings, as at d, e, and f, Fig. 38 (d), with the rib of each strip resting against the casting. The rib forms a guide to assist in lining the lead strips around the border of the opening. The lead is bent around the openings and fitted with the hands and by the use of a small rawhide mallet. Sheet brass hooks g, $\frac{1}{2}$ inch wide, are soldered to the strips of lead and hooked over the edge of the casting to aid in keeping the strips in place. Where the strips have to bend sidewise to form an arc, as for the parts d and f, it may be necessary to make saw cuts in one edge of the strip, as shown in view (g).

80. After the four strips of lead for each opening a, view (a), are bent to the correct shape and cut to length and fitted to each other at the corners, they are soldered together at the joints. The top section f, views (d) and (e), of the lead pattern is reinforced by a piece of lead h that is soldered to the top and side sections. This reinforcing strip is cut from a lead casting made from a wooden pattern $\frac{3}{8}$ inch thick and about 9 inches square. It may be cut with a hacksaw according to a paper pattern of the correct shape.

81. The brass hooks g, Fig. 38 (d), are next cut off with a hacksaw, and the lead pattern is removed from the casting. The removal of the hooks g must be carefully done so as not to change the shape of the pattern. After this is done, the three bosses i, view (f), made of $\frac{3}{8}$ inch thick lead, are soldered

in place. The bosses are located where the holes for the bolts used to hold the frame to the casting are needed. Excess solder must be put above the boss at *j*, view (*e*), so that the boss will have draft due to its location, and will draw readily from the sand.

82. Shrink Allowance on Lead Master Pattern.—A hard yellow-brass working pattern is cast from the lead master pattern, and consequently the master pattern must be made with a double shrink of $\frac{3}{16}$ inch per foot for the brass working pattern, and $\frac{3}{16}$ inch for the brass castings. This double shrinkage is taken care of on the lead master pattern by cutting the pattern in two along the center line *xx*, Fig. 38 (*f*), and placing a $\frac{3}{8}$-inch strip of lead between the halves of the bottom edge *d* and a $\frac{1}{4}$-inch strip between the halves of the top edge *h*. The difference in width of the lead insert in the top and bottom edges is due to the fact that the length of the top edge is less than the length of the bottom edge. The two sides *e* of the lead master pattern are also cut and $\frac{3}{8}$-inch lead inserts placed in the cut, after which all the edges are carefully soldered together. It is preferable to cut and patch one side at a time so as not to destroy the shape of the lead pattern.

83. Surface Finishing of Lead Master Pattern.—All joints of the pattern are next smoothed with beeswax and beeswax fillets are made around the three bosses. Two $\frac{1}{4}$-inch holes are drilled in the pattern to serve as draw holes. The pattern is finished by rubbing it with No. 0 sandpaper, which must be done lightly to prevent the abrasive from making deep cuts in the soft lead. A permanent finish is secured by using a flexible-shaft grinder, the final finish being obtained on a revolving drum covered with No. 0 sandpaper. Two No. 12 gauge draw holes are drilled in the pattern, after which it is ready for use.

METAL-PATTERN MAKING

(PART 2)

Serial 2233B Edition 1

METAL-PATTERN MOUNTING

GROUPING OF METAL PATTERNS

INTRODUCTION

1. Object of Reducing Pattern Weight.—One disadvantage of metal patterns is their weight. When a heavy metal pattern is being drawn out of the mold by hand, the molder is often unable to judge with certainty whether or not the pattern is striking the sides of the mold; in other words, he has lost the *feel* of the pattern. Therefore, the weight of a metal pattern should be reduced, whenever this can be done without injury to the form or strength of the pattern. Coring and drilling are the usual methods of making metal patterns lighter.

2. Dry-Sand Core Method of Reducing Pattern Weight. The weight of the white-metal pattern, Fig. 1 (a), may be reduced by casting its hub a on a dry-sand core as follows: The form of the core is shown at b, view (b). Such a core may be quickly and cheaply made from a large broken or scrapped dry-sand core. It is filed $\frac{3}{8}$ inch smaller in diameter than the boss a, so as to make the pattern $\frac{3}{16}$ inch thick. Its length is made the same as that of the hub. Three squares c are marked off on each end of the core, and the sand between the squares filed away to a depth of $\frac{3}{16}$ inch, after which a No. 20 hole is drilled through the center of the core. After a mold has been made of the master pattern and the pattern has been drawn from the mold, the dry-sand core b is placed centrally in the mold, as shown.

3. The three squares c, Fig. 1 (b), on each end of the core act as chaplets. A long nail d or a piece of No. 30 brass wire, bent over on one end and sharpened on the other end, is pushed through the hole in the center of the core and into the sand of the mold as shown, to keep the core from moving when the hub a is poured. The core is removed from the casting by scraping it out of the holes made by the squares c with a length

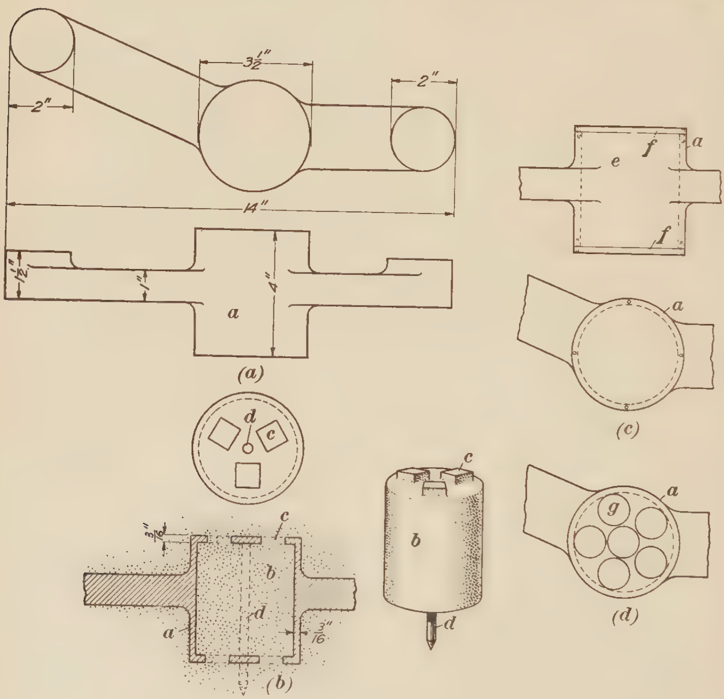


Fig. 1

of ¼-inch steel rod bent slightly on one end. The cavity made by the core b is stuffed full of paper or waste to form a support for the solder when filling the holes made in the ends of the hub by the squares c.

4. Wooden-Core Method of Reducing Pattern Weight. Another method of reducing the weight of a metal pattern as that in Fig. 1 (a) is to use a wooden core in place of a dry-

sand core. Dry pine wood from a scrapped pattern is preferred. Wet or green wood would form a gas when the metal is poured around it in the mold, and cause a blow that would spoil the casting. In order to prevent this, the wood core is charred with a blow torch until no white wood remains on the surface. The core is a cylindrical piece of wood turned to a diameter $\frac{3}{8}$ inch smaller than that of the hub *a*, Fig. 1 (*a*), and having a length $\frac{3}{8}$ inch less than that of the boss.

5. Three white-metal chaplets made of $\frac{3}{16}$ inch thick metal and about $\frac{1}{2}$ inch square are nailed on each end of the wood core with 3-penny nails driven through holes drilled in the chaplets with a No. 40 drill. The core is anchored in the sand of the mold with a long nail or wire as in the preceding method. After the casting is made, the nails that held the chaplets to the core are drawn out of the casting with a pair of pliers, and the brass wire that projects from the ends is sawed off. This method leaves the wooden core in the metal pattern.

6. Reducing Pattern Weight by Drilling.—A third method of reducing the weight of a metal pattern consists of boring a $3\frac{1}{8}$-inch hole *c*, Fig. 1 (*c*), through the hub *a* of the pattern which is held in a chuck on a lathe. Next, a layer of metal $\frac{3}{16}$ inch thick is turned off each end of the hub and brass disks *f* $\frac{3}{16}$ inch thick are riveted on the ends to cover the hole. If a lathe is not available, six $\frac{7}{8}$-inch holes *g*, view (*d*), may be drilled through the hub, after which $\frac{3}{16}$ inch of metal is ground off each end and $\frac{3}{16}$-inch brass disks are riveted on to close the ends of the holes.

HAND GATES FOR BRASS CASTINGS

7. Gating Metal Patterns.—When a large number of small castings, such as shown in Fig. 2 (*a*), is to be made by hand molding, several patterns are gated, or carded, to a common runner on a plate. The castings shown are used for brush holders on electric motors, and their dimensions must conform closely to those given on the drawing, view (*b*).

8. Wooden Master Pattern of Brush Holder.—The master pattern for the casting, Fig. 2 (*a*), is made of wood and is

shown in Fig. 3 (*a*). It must be made with a double shrink of $\frac{15}{64}$ inch per foot to take care of the $\frac{3}{64}$-inch per foot shrink of the white-metal working pattern cast from the master pattern and the $\frac{3}{16}$-inch per foot shrink of the brass casting made from the working pattern. The small amount of $\frac{3}{64}$ inch

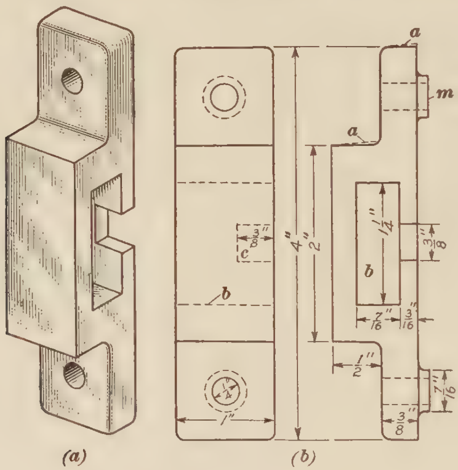


FIG. 2

per foot allowance for shrink of the white metal is given to the master pattern as it is not practical to rap the pattern in the mold to provide the necessary allowance, as is frequently done with some patterns. The draft on the master pattern is $\frac{1}{64}$ inch on all sides and is in a direction as indicated by the dotted lines *a* in Fig. 2 (*b*). The rectangular hole *b* through the casting and the square notch *c* are cored out with a dry-sand core, necessitating the use of the core prints *d* and *e* on the master pattern, Fig. 3. The $\frac{3}{8}$-inch square notch in the side of the hole is formed by a boss $\frac{3}{8}'' \times \frac{3}{8}'' \times \frac{3}{16}''$ on the core. The object of the bevel *f* on the print *d* is to enable the molder to use this print as a guide in setting the core in the mold.

9. As the patterns are to be fastened to a common runner, a connection *g*, Fig. 3, must be put on the master pattern. This may be made from a brass gate, view (*c*), as usually kept in stock, by cutting off the flat end *h* along the line *xx*, and

drilling two small holes in the end of *g* and driving two short lengths *i*, views (*a*) and (*b*), of No. 40 brass rod into the holes. The projecting ends of the rods are sharpened and driven into the end of the wood master pattern, care being taken to fasten the connection *g* $\frac{1}{16}$ inch below the cope line as shown, in order to provide a ridge, or notch, *j* on the castings where the gates are to be cut off.

10. If it is required to connect ten of the white-metal patterns to a common runner by gates, as shown in Fig. 4, ten brass connections, Fig. 3 (*c*), are required. They are tinned on the part *h* and laid in the depressions in the mold made by the print *g*, view (*a*), of the wood master pattern, so that the

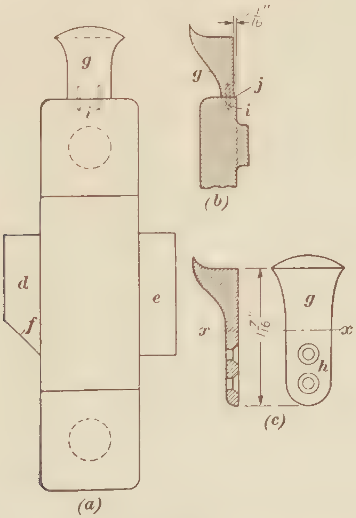


FIG. 3

ends *h* will be cast solid in the white-metal patterns. The runner *k*, Fig. 4, is made $10\frac{3}{4}$ inches long, and is shown in Fig. 5. Two $\frac{1}{4}$-inch brass rods *l*, Fig. 4, 2 inches long and rounded at one end, are driven into holes drilled through each end of the runner. These pins are used by the molder to steady the gate of patterns while drawing it out of the mold. The pins must be perfectly straight and square with the runner, otherwise the patterns will not draw without damaging the mold.

After the ten white-metal working patterns have been cast from the master pattern, they are filed to size. The brass con-

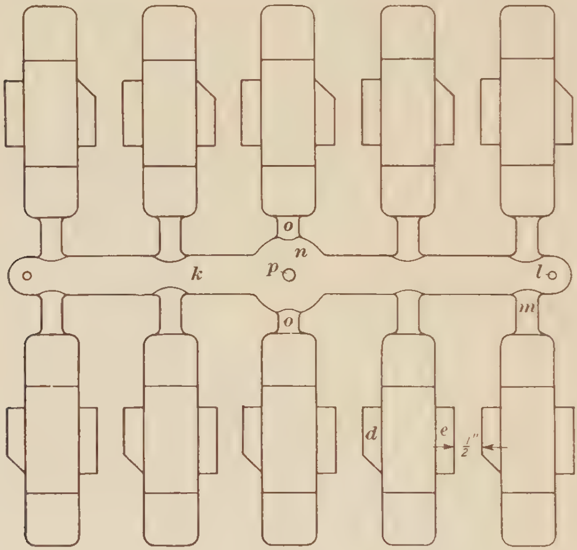


Fig. 4

necting pieces *m* that were cast in them are heated with a large soldering copper, and solder added to make sure that they are fastened securely. Care must be taken to finish all the patterns to exactly the same size in order to enable the cores to

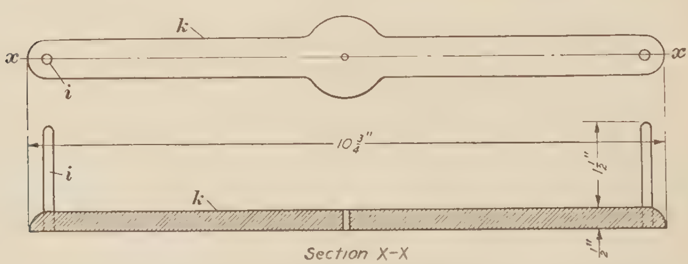


Fig. 5

fit any of the core prints. The patterns must be finished very smooth, and this can be done with No. 00 sandpaper.

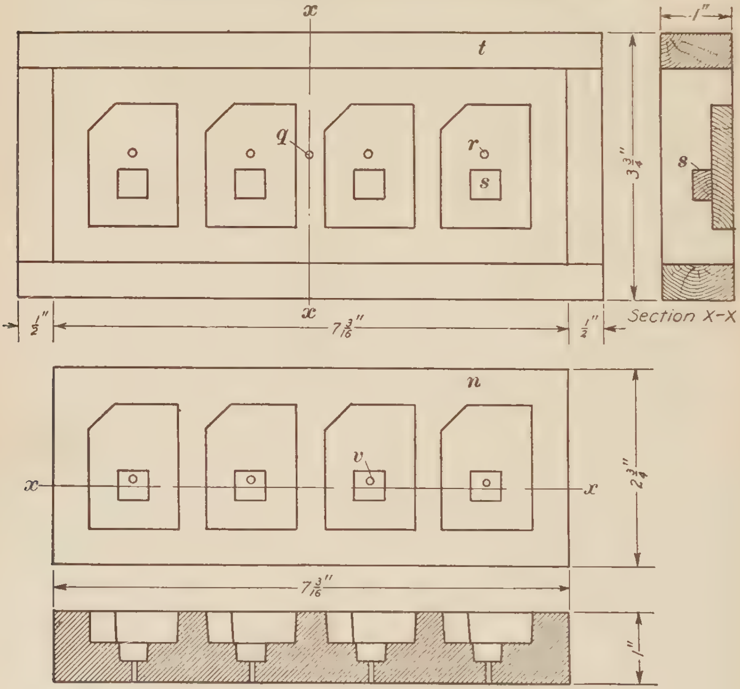
11. The runner k, Fig. 4, is next put on a parallel $\frac{3}{16}$ inch high and $\frac{3}{4}$ inch wide, located on a surface plate that has been covered with paper to protect it from the soldering acid. The metal patterns are lined up along the runner as shown, with the $\frac{7}{16}$-inch diameter bosses m, Fig. 2 (b), resting on the surface plate and the core prints $\frac{1}{2}$ inch apart. The two center patterns are placed opposite the sprue boss n, Fig. 4, on the runner k, and the brass connecting pieces o are sawed off so as to make the ends of all the patterns fall in a straight line. All the connecting pieces are then sweated to the runner, the excess solder being removed with a half-round solder file, and the finishing of the rough places is done with No. 0 sandpaper. A hole p is made with a No. 12 drill in the center of the boss n for a drawhole. The gate of patterns is now ready for use in the foundry.

12. Aluminum Core Box for Brush Holder.—The core box for the dry-sand core to form the rectangular hole b, Fig. 2 (b), in the pattern is made as follows: First, a wood master pattern of the core including the core prints is made, and then four white-metal core patterns are cast from the single master pattern. The metal core patterns are used to make a plaster of Paris core box pattern by pouring plaster around them. Finally, an aluminum core box is cast in a sand mold made from the plaster core-box pattern.

The wood master pattern of the core is made with a double shrink of $\frac{3}{64}$ inch per foot for the white-metal core patterns and $\frac{3}{16}$ inch per foot for the brass castings of the brush holder, Fig. 2 (a). This does not take into account the shrinkage of the aluminum core-box casting which may be neglected since the shrinkage of the aluminum casting in the rectangular holes will just be sufficient to allow finishing of the holes with files and scrapers. The core pattern has draft on all its edges in the same direction as that of the draft on the core prints on the patterns, Fig. 3. Four white-metal core patterns are cast in sand from the wooden master pattern and finished to size with a flat solder file, and by using No. 00 sandpaper, after which the dimensions are carefully checked with those of the

prints *d* and *e*. This is important, because the cores must fit the depressions made in the mold by these prints.

13. A drawhole *r*, Fig. 6, is drilled through the center of each of the four white-metal core patterns, and four patterns are placed on a surface plate with the square projection *s* on top. A wooden frame *t*, $\frac{1}{2}$ inch thick, 1 inch high and having



Section X-X

Fig. 6

an inside width of $2\frac{3}{4}$ inches and a length of $7\frac{3}{16}$ inches is placed around the patterns, as shown. This frame leaves a space of $\frac{1}{2}$ inch all around the castings. The inside of the frame, the four patterns, and the surface plate inside the frame are coated with thin grease made by mixing together hot beeswax, paraffin, and machine oil. The frame is then weighted down on the plate by placing a bar of iron or lead across it, and filled with plaster of Paris. The object of the weight on

the frame is to prevent the plaster from floating the frame and running out. In mixing the plaster, about one-half as much water as would fill the frame is placed in a pail and the plaster is sprinkled over the surface of the water, and allowed to sink to the bottom without being stirred. When the plaster begins to show above the surface and no more will sink, the mass is then thoroughly stirred with a broad stick until all the air bubbles have disappeared from the top. The plaster is then ready to be poured.

14. Plaster in setting generates heat so that as soon as the plaster in the frame becomes warm, it is solid enough for the frame to be turned over. The metal patterns are removed by screwing a large wood screw into the drawhole in each pattern and striking the pattern a light hammer blow, after which the patterns may be easily drawn out of the plaster. The frame *t*, Fig. 6, is then pried apart with a screwdriver and removed from the block of plaster, draft being given to the sides of the block by cutting with a sharp knife. Next, a thin coat of yellow shellac is brushed over the entire block. The shellac must be thinned with alcohol or the dampness of the plaster will cause the shellac to peel off after it dries. A No. 12 drawhole *q* is drilled through the center of the block which is used as a pattern for casting an aluminum core box *n* in a sand mold. No shrinkage allowance for the aluminum is necessary as the amount that the casting will shrink is just enough so that the inside of the core box can be filed and finished. The face of the aluminum core box is ground true on a disk grinder, and the recesses in which the cores are to be formed are filed and scraped to the dimensions of the core prints on the working patterns. The final smoothing is done with No. 0 sandpaper.

15. A No. 40 hole *v*, Fig. 6, is drilled through the bottom of the aluminum core box in each of the core holes. These holes serve to relieve the vacuum created when the cores are being removed from the core box. All outside edges of the box are ground to a curve of $\frac{1}{4}$ inch radius to make the box easy to handle. The inside dimensions of the finished box are

then checked by making a set of plaster cores in the box and checking the dimensions of the cores with those of the prints *d* and *e*, Fig. 3. Finally, the core box is stamped or numbered with the same identification marks as the patterns with which the cores are to be used.

GATING PATTERNS FOR THIN CORED IRON CASTINGS

16. Method of Gating Thin Patterns.—Let it be required to make a gate of patterns for the iron casting the drawings for which are shown in Fig. 7. This is a small by-pass valve.

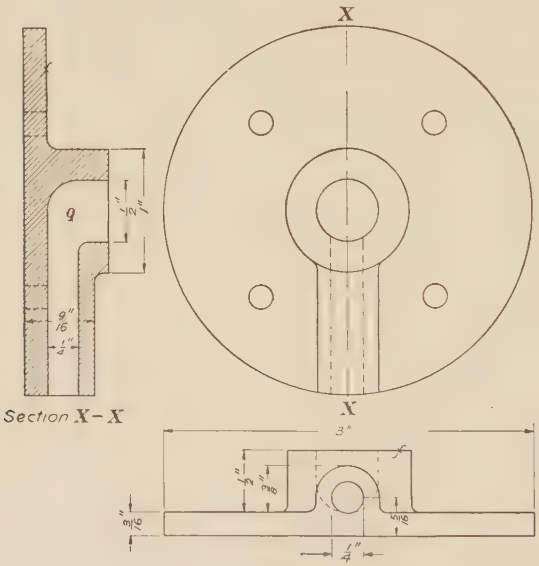


Fig. 7

This casting must be made to very close measurements and in large numbers so it is desirable to make a brass master pattern to produce the set of aluminum working patterns. A metal master pattern is always to be preferred to any other kind, if the conditions warrant the extra cost, because the castings made from the working patterns will be smoother and require less finishing. The brass master pattern is made by turning, in a lathe, a brass boss 3 inches in diameter and $\frac{9}{32}$ inch thick. This forms the base *a*, Fig. 8 (*a*), of the pattern. The thickness of $\frac{9}{32}$ inch is

necessary to take care of the finish required on the top surface of the base, as indicated by the finish mark on the working drawing. The allowance for finish on metal patterns where there are finish marks on the drawing is usually $\frac{3}{32}$ inch, making the required thickness $\frac{3}{16}$ inch + $\frac{3}{32}$ inch = $\frac{9}{32}$ inch. In some cases the allowance for finish is $\frac{1}{8}$ inch. The edge of the base is given a taper of $\frac{1}{64}$ inch per inch to take care of the required draft on the pattern. The master pattern is made with

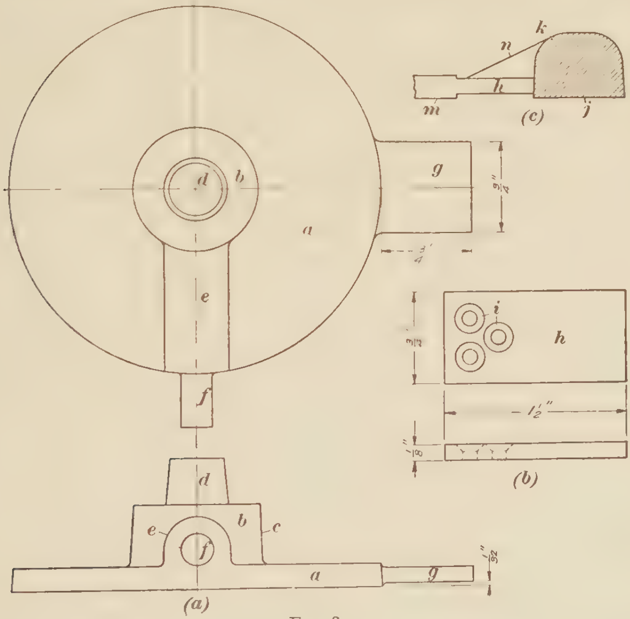


FIG. 8

a double shrinkage of $\frac{1}{8}$ inch per foot for the iron castings and $\frac{5}{32}$ inch per foot for the aluminum working patterns, making a total shrink of $\frac{9}{32}$ inch per foot.

17. Unless a special shrink rule having a shrink of $\frac{9}{32}$ inch per foot is available, it will be necessary to compute the master pattern dimensions to take care of the shrink. This is best illustrated by the following example. The base *a*, Fig. 8, of the master pattern has a diameter of 3 inches, as indicated on the working drawing. A shrink of $\frac{9}{32}$ inch per foot is equivalent

to a shrink of $\frac{9}{32} \div 12 = .024$ inch per inch, and the 3-inch diameter of the base would therefore be increased by an amount equal to $3 \times .024 = .072$ inch, making a total diameter of 3.072 inches.

18. The large boss *b*, Fig. 8 (*a*), of the master pattern for the casting shown in Fig. 7 is of white metal, and turned with draft as indicated by *c*, view (*a*). It must have a length of $\frac{1}{2}$ inch plus the extra stock necessary to take care of the finish, or a total length of $\frac{1}{2}+\frac{3}{32}=\frac{19}{32}$ inch. Next, a core print *d* made of $\frac{1}{2}$-inch diameter brass rod is turned to size in a lathe, after which the base *a*, the boss *b*, and the core print *d* are put together with a single No. 30 brass rivet through the center of the three parts.

19. The raised part *e*, Fig. 8 (*a*), of the pattern is made of brass rod $\frac{1}{2}$ inch in diameter and $1\frac{1}{8}$ inches long. A flat face is then ground on one side of the rod, and the rod is placed on top of the base *a* of the pattern. Enough metal must be ground off the rod to make the center of the rod $\frac{5}{16}$ inch higher than the bottom surface of the base *a*, as shown in Fig. 7. The rod is then soldered in place on the base. A $\frac{1}{4}$-inch hole $\frac{3}{8}$ inch deep is drilled in the center of the rod and a piece of $\frac{1}{4}$-inch brass rod $\frac{3}{4}$ inch long is driven into the hole, forming a core print *f*, Fig. 8 (*a*), $\frac{3}{8}$ inch long. A print *g*, to take care of the runner connection, is made of sheet brass $\frac{1}{8}$ inch thick, $\frac{3}{4}$ inch wide and $\frac{3}{4}$ inch long, and is soldered to the base *a* $\frac{1}{32}$ inch below the cope line. The excess solder is removed with a half-round solder file and all fillets are put in with wax filler. The master pattern is finished with No. 00 sandpaper.

20. The number of working patterns that can be combined into one gate of patterns depends on the size of flask used. If four working patterns are used, as shown in Fig. 9, four runner connections *h* are necessary. One of these connections is shown in detail in Fig. 8 (*b*). These are made of cold-rolled steel $\frac{1}{8}$ inch thick, $\frac{3}{4}$ inch wide and $1\frac{1}{2}$ inches long. Three holes *i* are drilled into the end of each connection with a No. 10 drill and afterwards countersunk, as shown. The connections *h*

are tinned, so that one steel connection can be cast into each pattern casting. The castings are checked as to dimensions and filed and scraped to size.

21. In Fig. 8 (c) is shown how the joint between the runner j and the connecting pieces h is made. The runner is a brass casting 6 inches long having the edges k rounded off to a

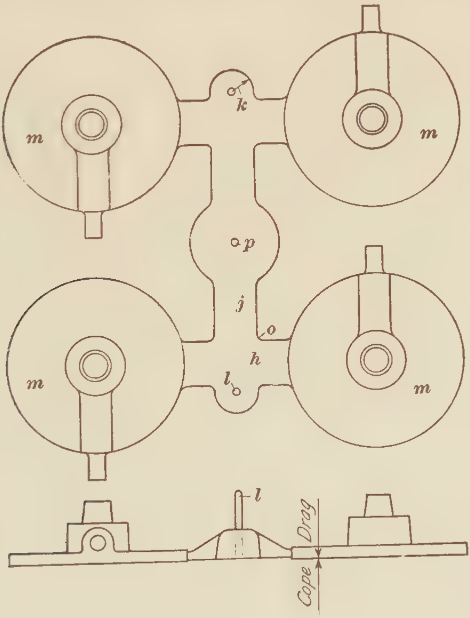


FIG. 9

radius of $\frac{3}{8}$ inch; the ends, as at k, Fig. 9, are also rounded to a like radius. A $\frac{1}{4}$-inch diameter brass steady-pin l $1\frac{1}{2}$ inches long is placed at each end of the runner. As the pattern m, Fig. 8 (c), is $\frac{1}{32}$ inch lower than the runner j, the latter is placed on a surface plate with a small piece of $\frac{1}{32}$-inch thick sheet brass under each end and one under the middle. The connecting pieces h and the patterns m are then lined up on the surface plate in the correct position relative to the runner, as shown in Fig. 9, and four brass wedges n, Fig. 8 (c), or fillers, are placed on top of the connections h and against the runner j;

the whole assembly is then sweated together with a large soldering copper. It may happen that the soldering causes one of the patterns to rise above the others in cooling and shrinking. This can be corrected by striking the high pattern lightly with a rawhide mallet until it is level with the others. The excess solder is removed and used to build up fillets, such as shown at *o*, Fig. 9, between the connections and runner. The core prints are usually stamped with the mark *Core*. A No. 12 drawhole *p* is drilled in the center of the runner, after which the gate of patterns is ready for use.

22. Patching Blowholes in Aluminum Patterns.—If the aluminum patterns cast from the master pattern are not sound, but show blow holes or small bubble holes on the cope side, they can be patched with aluminum solder in the following manner. First, the casting must be scraped bright and clean with a three-cornered scraper. Sandpaper or emery cloth cannot be used for this purpose, as the glue which binds the abrasive particles will be worked into the face of the casting and prevent the aluminum solder from fusing to it. The casting is then heated with a blow torch until it is hot enough to melt solder applied to the surface. A small amount of solder then is brushed into the surface with a wire brush until the face of the casting and the walls of the blowholes are thoroughly coated with the solder. The holes are then filled with the solder and the casting is allowed to cool. It is not good practice to quench the casting in water, as the difference in the amount of shrink of the solder and of the casting is sufficient to crack the solder. If the casting has a hollow surface, it is first coated by scratch-brushing the surface while the aluminum solder is applied, after which a solder consisting of a mixture of lead and tin is used to build up the hollow surface.

23. Core Box for Valve By-Pass Casting.—The core for the casting shown in Fig. 7 is shown at *a* in Fig. 10 (*a*), as rammed up in a two-part aluminum core box made for four cores. The core box is made of machined aluminum bars *b*, *c*, and *d* cast from the wooden patterns shown in views (*b*) and (*c*). The dimensions of the finished bars are given in

views (c) and (d), together with the locations and the sizes of the holes that must be drilled and finished in the parting lines of the aluminum core box. The two bars d, view (d), are mated and one is riveted to the part b and one to the part c.

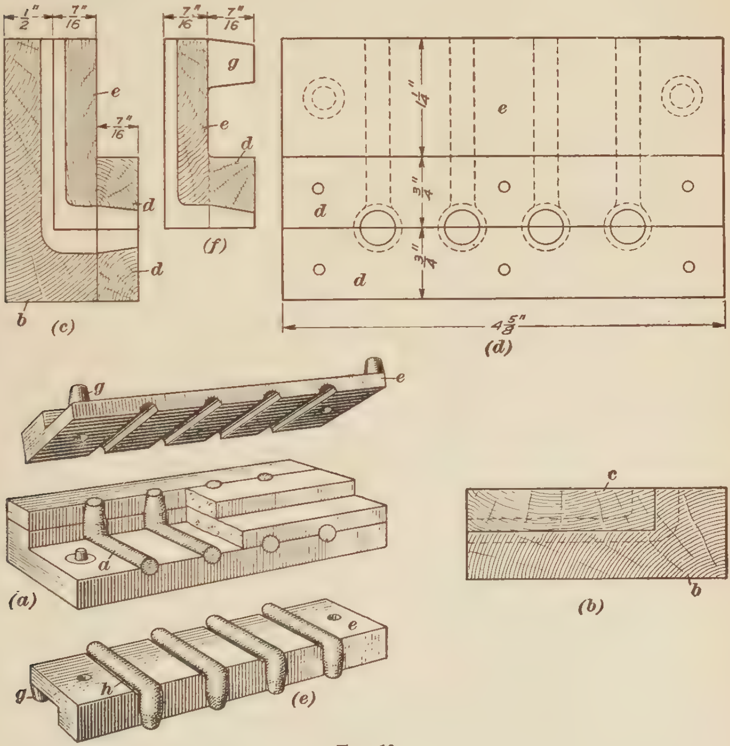


FIG. 10

24. Pins for Aluminum Core Boxes.—As aluminum is a soft metal, the ordinary core-box pins will soon wear loose. Therefore, the type of pins shown in Fig. 11 (a) and (b) is preferable. The socket x is screwed into one part of the core box, and the corresponding pin y is screwed into the mating part, as shown in view (a). The two parts of the box are clamped together and a hole is drilled through them. The hole is then sized by the reamer u, view (c), which is provided with an adjustable depth stop v, and is then threaded by the tap w

which has a pilot to prevent the tap from starting at an angle. The socket x and the pin y are screwed into the holes by use of the double-end wrench z, view (b).

25. Aluminum Drier for Valve By-Pass Cores.—As the cores made in the core box shown in Fig. 10 (a) cannot be laid on a flat plate to be dried in the core oven, a drier such as shown

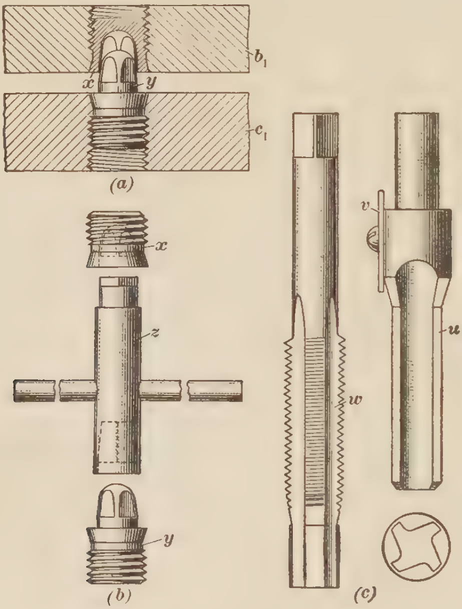


FIG. 11

in view (e) is needed. This drier is made of cast aluminum and is similar to the top part of the core box. When the cores have been rammed up in the core box, the top part of the box is removed and replaced by the drier e, after which the box is rolled over, and the bottom part of the core box, which is now on top, is removed. This leaves the sand cores resting on the drier, as in view (e), and the drier may then be placed in the oven.

To cast the drier, the part c, view (c), of the core box, together with the attached part d, is modified and used as a pattern, as shown in view (f). The pin bushings are first removed

and the holes filled with beeswax. A small **V**-shaped depression is made in the center of the beeswax so that the centers of the bushing holes may be preserved on the casting of the drier made from the pattern. Two wooden bosses g $\frac{1}{2}$ inch in diameter and $\frac{7}{16}$ inch high are glued temporarily to the corners of the pattern e in order to enable the driers to stand level in the core oven.

26. A white-metal working pattern of the drier is made from the temporary pattern shown in Fig. 10 (e). The casting must be accurately fitted to the bottom part b, view (c), of the core box. In order to do this, a plaster core is made in the core box. Then the top part c of the box is replaced by the casting of the drier and fitted to the bottom part b. With the plaster core in place, the drier casting is scraped until it rests accurately on the bottom part b of the core box. The shrinkage of the casting allows enough metal for the casting to be scraped to size. In order to enable the oven heat to strike most of the surface of the core when placed in the drier, $\frac{1}{32}$ inch of metal is scraped from the sides of the holes in the drier pattern, as shown at h in view (e). This vents the lower sides of the core and prevents the top of the core from burning before the bottom is dry. A number of aluminum castings for driers are made from the temporary white-metal drier pattern, and $\frac{7}{64}$-inch holes are drilled in the center of the **V**-shaped location marks. The holes so produced in the drier castings will fit the pins on the bottom part of the core box cast from the part b, view (c). The temporary bosses g used for feet on the top part e of the core box are removed, and the wax taken from the holes so that the bushings can be replaced and the core box used as intended.

HAND GATE FOR MALLEABLE CASTINGS

27. Gating Patterns for Malleable Castings.—Metal patterns for white-iron castings used to make malleable iron are gated more heavily than are metal patterns for brass and gray-iron castings, to allow for the greater shrinkage of the white iron. As an example, suppose it is desired to make the valve by-pass shown in Fig. 7 of malleable iron. The master pattern

is the same as for the gray-iron castings. The aluminum working patterns are connected to a common runner *a*, Fig. 12 (*a*), made of cast brass, having a larger area than runners for gray iron. The larger area is obtained by making the corners at the top of the runner with a short radius, instead of with a semicircular top as is used for gray iron. Furthermore, the runner is placed in the cope side of the mold so as to act as a pressure feeder to the castings. It is necessary to place the steady pins *b* on the flat side of the runner.

28. Use of Shrink Head for Malleable Castings.—In addition to the use of a heavy runner located in the cope as a pressure feeder, it is necessary to use a shrink head on each pattern gate, as shown at *e*, Figs. 12 and 13. After the runner *a*, Fig. 12 (*a*), has been placed on a surface plate with the steady

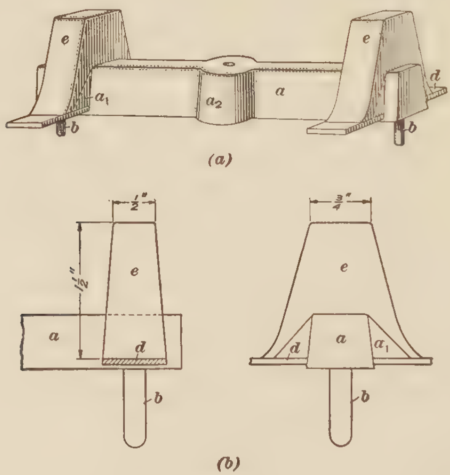


Fig. 12

pins *b* facing upwards, the patterns *c*, Fig. 13, are lined up on both sides of the runner, two on each side. The patterns are then sweated to the connecting pieces, and the latter to the runner, after which the gate of patterns is turned over and brass fillers a_1, or wedges, are placed on the connecting pieces *d*. These fillers are soldered to the connecting pieces and to the

runner to make the gate more rigid. The sprue is set on the boss a_2.

The shrink-head pattern e is made of white metal from a wooden pattern, and is soldered in place between the patterns

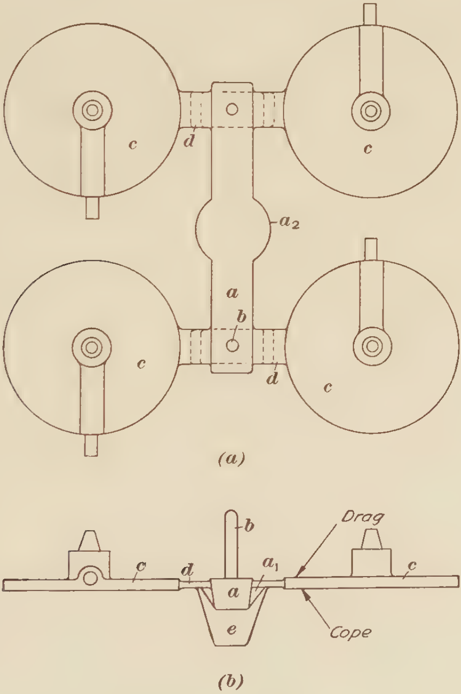


FIG. 13

and across the runner and wedge as shown in detail in Fig. 12 (b). The excess solder is removed with a half-round solder file. The shrink-head has a draft of $\frac{1}{8}$ inch or more, and large fillets are made of solder all around it on the runner.

MOUNTING PATTERNS ON MOLDING MACHINES

FIXTURES FOR METAL PATTERNS

29. General Remarks.—In mounting metal patterns on molding machines, the patterns are fastened to a plate which is either fastened directly to the molding machine, or in a fixture which is fastened to the table of the molding machine. The tables of molding machines on which the pattern plates are mounted are either flat or consist of two parallel bars. Usually

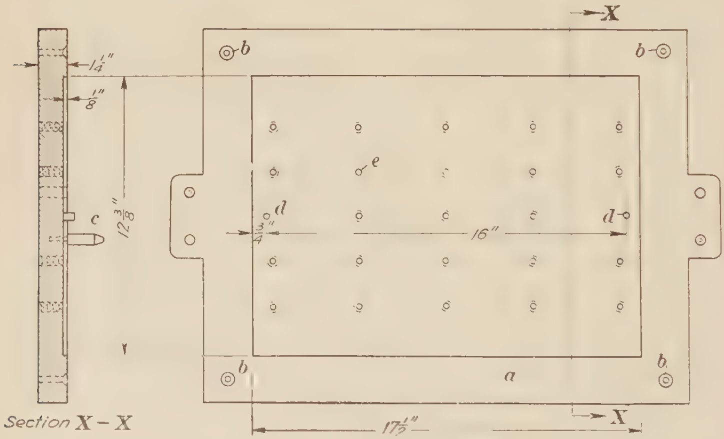


FIG. 14

four flat-head machine screws or hexagon-head bolts are used to fasten the pattern plate or fixture to the molding machine table. For light and medium-weight castings, a fixture is made to which is fastened a $\frac{1}{8}$-inch-thick sheet steel plate, on which the patterns are mounted. Such fixtures are made standard for all plates that are molded in a certain size of flask, and the different sizes of plates and fixtures are made corresponding to the various sizes of flasks and the capacities of the molding machines used.

30. Construction of Molding-Machine Fixture.—Heavy patterns are mounted on a cast aluminum or on a cast-iron plate, which is fastened to the molding machine table by four hexagon-

head bolts. As an example, let it be required to make a pattern mounting for a $13'' \times 18''$ flask. First, a cast-iron fixture is made as shown at *a* in Fig. 14. This fixture is fastened on top of the ways of a molding machine by four $\frac{3}{8}$-inch flat-head machine screws, through the countersunk holes *b*. In order to locate the pattern plate accurately on the fixture with respect to the flask pins *c*, two pins *d* are provided on the fixture. The pins *d* are $\frac{5}{16}$ inch in diameter and $\frac{1}{4}$ inch high, and are placed on the center line of the fixture at a distance of $\frac{3}{4}$ inch from the edge of the depression in which the pattern plate fits. The holes *e* are drilled and tapped for No. 12-24 flat-head machine screws and are used to fasten the pattern plate to the fixture. These holes are slightly countersunk to accommodate the portion of the screw head that projects through the pattern plate.

31. Pattern-Plate Construction.—The dimensions of the pattern plate to be used on the fixture shown in Fig. 14 and illustrated in Fig. 15 are made slightly smaller than the corresponding dimensions of the flask to be used with the fixture. The plate is made $12\frac{3}{8}$ inches wide and $17\frac{1}{2}$ inches long, and the edges are machined square so that the plate will fit the depression in the fixture. The thickness of the plate is $\frac{1}{8}$ inch and must be very uniform. It is customary to give the thickness as .125 inch with an allowance of .005 inch plus or minus. If the plate is thin at one end or corner, the castings from the patterns mounted near the thin part of the plate will have a bad parting line as the sand at this end will be crushed when the mold is closed. To make the plate perfectly straight, it is placed on a surface plate and straightened with a rawhide mallet. It is preferable to use a rawhide mallet rather than a steel hammer, as the latter dents the surface of the plate, and thus causes kinks and swells that prevent the patterns from fitting tightly to the plate and may cause the sand to stick to the plate. The thin natural scale on the pattern plate is not usually removed, as it furnishes a protection against rust in the damp foundry sand. When the edges of the plate become upset or nicked in handling, they should be corrected by filing so as to enable the plate to seat perfectly in the fixture.

32. Construction of Drilling Jig for Molding-Machine Fixture.—The holes f, Fig. 15, used to locate the plate in the molding machine fixture must be on the horizontal center line

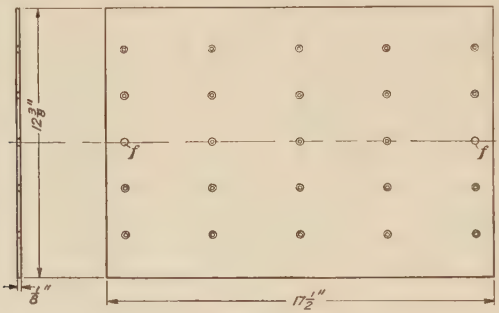


FIG. 15

and the distance between them must be the same as the distance between the pins d of the fixture shown in Fig. 14. In order to locate the holes accurately, the plate is placed in a jig such as shown in Fig. 16, having guides g at the four corners, by which the plate is prevented from moving. The dimensions of the jig plate, which is made of machine steel, are exactly those of the depression in the fixture, and for the sake of lightness, the inner

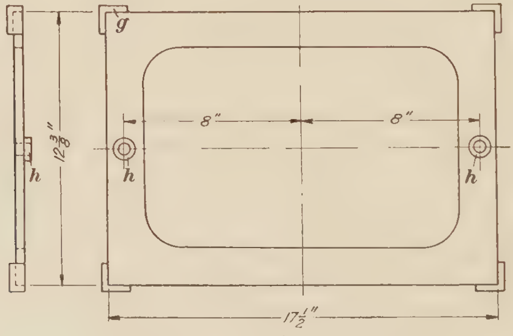


FIG. 16

portion of the jig plate may be cut out as shown. The jig has two bushings h located on the horizontal center line exactly 16 inches between centers and on opposite sides of and at equal distances from the vertical center line. The pattern plate,

Fig. 15, is placed in the jig between the guides g and two $\frac{19}{64}$-inch holes f are drilled through the jig bushings in the plate, after which a $\frac{5}{16}$-inch diameter straight reamer is run into the holes about half the length of the reamer, which makes the hole a sliding fit for the pins d on the fixture, Fig. 14.

33. Another jig shown in Fig. 17 is used for drilling the holes for the screws that hold the pattern plate down on the molding-machine fixture. The outside dimensions of the jig are the same as those of the depression in the fixture, Fig. 14, and the pattern plate, Fig. 15, is held on the jig between the

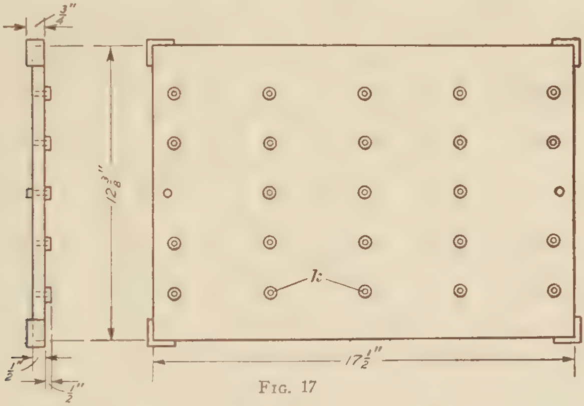


Fig. 17

four corner guides, Fig. 17. Two pins $\frac{5}{16}$ inch in diameter fitted to the jig are used to locate the position of the pattern plate by means of the holes f, Fig. 15, into which they fit.

34. The jig, Fig. 17, is provided with a number of bushings k $\frac{1}{2}$ inch in diameter and having holes in them through which a No. 12 drill is run into the pattern plate. The plate is then removed and the holes countersunk for a No. 12-24 flathead machine screw. Care must be taken not to run the countersink in too deep, as the thickness of the pattern plate is $\frac{1}{8}$ inch and the head of the screw is $\frac{7}{64}$ inch high. The plate is finally filed on the faces to remove all burrs, and is then ready to have the patterns mounted on it.

EXAMPLE OF FIXTURE MOUNTING

35. Master and Working Pattern of Clevis.—Let the pattern be for the clevis shown in Fig. 18 (*a*). The $1\frac{1}{2}$-inch hole in the end of the casting, shown in (*b*), is not cored but drilled. The maximum width is $2\frac{1}{8}$ inches and the length 5 inches, enabling 12 half patterns to be mounted on a pattern plate in the following manner. The master pattern is made of wood with a double shrink of $\frac{1}{8}$ inch per foot for the casting and $\frac{3}{64}$ inch per foot for the white-metal working pattern. The

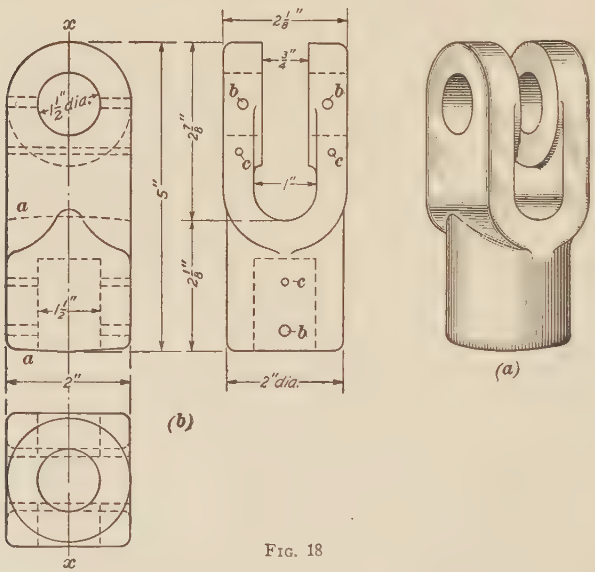


Fig. 18

master pattern is made in two parts, the parting line being the line *x-x*, view (*b*). The dimensions of the pattern are accurately checked before it is molded. Six white-metal castings are made from each half of the master pattern to serve as working patterns. The dimensions of the white-metal castings are also carefully checked especially the width of the slot which is the most important and must be made absolutely correct, while the other dimensions may vary by $\frac{1}{64}$ inch. The faces of the half patterns are ground true on a sandpaper-

disk grinding machine, so that they will fit the pattern plate closely.

36. The patterns are finished in pairs; that is, two halves are soldered together with a small amount of solder at the edges, and finished as a complete pattern. The draft is indicated at *a*, Fig. 18, and is made about $\frac{3}{64}$ inch. When the patterns are finished to size, they are sandpapered with No. 0 sandpaper, care being taken to make all the polish marks in the same direction as the draft. Three drive-fit holes *b* $\frac{1}{4}$ inch in diameter are drilled through the patterns for dowel pins used to hold the patterns in position on the pattern plate. These holes should be located as nearly central as possible, and preferably in the heavy parts of the pattern. After both halves

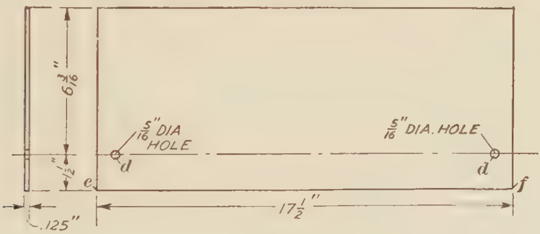


FIG. 19

of each pattern have been stamped with the same steel stamp so that they can be assembled correctly at any time, the end of the pattern is struck lightly with a rawhide mallet, which causes the solder to break and the two halves of the pattern to be separated. The excess solder is then carefully removed from the half patterns by filing, after which three holes *c* are drilled with a No. 12 drill in each half pattern and tapped for a No. 12-24 flat-head machine screw. These screws fasten the patterns to the plate and their location is relatively unimportant, except that they should be distributed around the pattern to be most effective.

37. Mounting Patterns of Clevis on Plate.—A temporary jig shown in Fig. 19 is made of sheet steel $\frac{1}{8}$ inch thick and of the same length as the pattern plate shown in Fig. 20, but only half as wide. Six half-patterns, one of each pair, are laid out

on this jig exactly as they are to be mounted on the pattern plate. They are held in place by running wax filler around the edges of each half-pattern with a hot soldering copper. When the wax has set, a $\frac{1}{4}$-inch drill is run through the holes *b*, of the patterns, Fig. 18, into the jig plate, care being taken not to move the patterns while drilling. The patterns are then removed by heating the jig, after which the jig is stamped with the same marks as on the half patterns, at the locations from which they

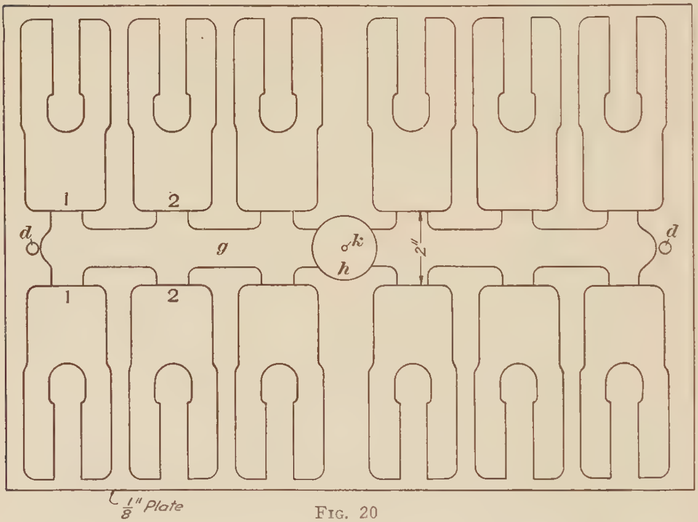


Fig. 20

are removed. The jig is then placed on the top half of the pattern plate, being guided by two steel dowel pins $\frac{5}{16}$ inch in diameter fitted in the locating holes *d* in both the jig and pattern plate.

38. With the jig shown in Fig. 19 in the correct position on the pattern, a $\frac{1}{4}$-inch drill is run through the holes that were drilled through the half patterns into the jig. After all the holes have been drilled in the pattern plate in this way, the jig is turned over on the pattern plate. In turning the jig over, the locating holes *d* are kept together, or in other words, the jig is turned on the line *ef* so as to cover the lower half of the

pattern plate, and the process of running the $\frac{1}{4}$-inch drill through the jig and the pattern plate is repeated. The markings or stampings on the jig are transferred to the plate in their correct location, and the jig is removed. The patterns may then be located on the plate by driving steel pins of $\frac{1}{4}$ inch diameter and $1\frac{1}{8}$ inches long through the holes *b*, Fig. 18, of the patterns into the plate. The markings on the patterns must correspond to those on the plate, so that the pattern marked No. 1 in the top row of patterns will be opposite pattern No. 1 in the bottom row, as shown in Fig. 20. A No. 12 drill is then run through the holes *c*, Fig. 18, of the pattern into and through the plate which is then turned over to enable the holes to be countersunk for receiving No. 12-24 flat-head machine screws. The screws are then put in place and screwed in tightly so as to force the half pattern to bear snugly against the plate.

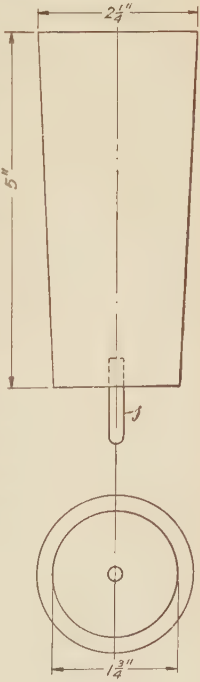


FIG. 21

39. Gating of Clevis Patterns.—The runner *g*, Fig. 20, is made of white metal $\frac{3}{4}$ inch thick, 2 inches wide, and $15\frac{1}{2}$ inches long. The width of the runner just equals the distance between the rows of patterns, and to make the gates to the patterns the excess metal in the runner is melted out roughly by means of a soldering copper, after which the gates are finished with a half-round solder file. The two ends of the runner are made with a radius of $\frac{5}{8}$ inch. The boss *h* on the runner serves to receive the sprue which is cast of aluminum from a wood master pattern kept in stock for making sprues for other plate jobs. The metal sprue, Fig. 21, has a $\frac{3}{16}$-inch steel pin *j*. The pin *j* is set in the $\frac{1}{4}$-inch hole *k*, Fig. 20, in the center of the boss *h* and holds the sprue in the right place while making the cope side of the mold; the sprue is left out in making the drag side.

40. The runner *g*, Fig. 20, is finished with No. 00 sandpaper, and then fastened to the pattern plate in the center between the two rows of half patterns by four No. 10-32 flathead machine screws spaced evenly along the runner. First, the holes are drilled through the runner and pattern plate with a No. 20 drill, after which the holes in the pattern plate are tapped with a No. 10-32 tap, while the holes in the runner are widened by running a No. 9 drill through them. The holes in the runner are countersunk to receive No. 10-32 flat-head machine screws which fasten the runner solidly against the plate. The screw heads are soldered over and finished flush with the top of the runner with a flat solder file, while the projecting screw ends and all burrs are filed flush with the back of the plate.

41. It will be noted from Fig. 20 that the length of the runner *g* is such as to leave the holes *d* uncovered. These holes are for the pins *d*, Fig. 14, of the fixture. In some cases the runner covers some of the holes for the screws that fasten the plate on the fixture. In that case, two holes are drilled through the runner and the plate with a No. 12 drill and the hole through the runner is widened by running a No. 1 drill through from the pattern side of the plate. The holes in the runner are countersunk to receive No. 12-24 flat-head machine screws which are screwed into tapped holes in the molding machine fixture. Beeswax is used to fill the countersunk holes after the plate is screwed on to the fixture. When it is desired to loosen the plate from the fixture, the beeswax is melted out after which the screws can be removed.

42. Generally the pattern plate is stamped so as to indicate the manner of molding. In this case, the plate would be stamped: *One Plate Cope and Drag,* which means that both cope and drag are made on the same plate thus producing 12 castings in one mold. The impressions of the right-hand set of half patterns in the drag matches those of the left-hand set in the cope and similarly, the left-hand set in the drag matches the right-hand set in the cope. When the mold is

poured, the iron flask is not removed from the mold as is usually done when a snap flask is used, as the castings are formed so close to the sides of the mold that the iron would break through if the sides were left unprotected.

PATTERNS AND CORE BOXES FOR AUTOMOBILE PISTON

43. **Requirements of Piston Patterns.**—Cast-iron automobile pistons are cast in sand molds by means of multiple metal patterns on molding machines. The alloy pistons may be cast in permanent metal molds. A view of a light-weight, or skeleton, cast-iron piston is shown in Fig. 22 (*a*) and mechanical drawings of it are given in views (*b*), (*c*), and (*d*). The body of this piston has four large rectangular openings, and its thickness ranges from $\frac{3}{32}$ inch to $\frac{7}{32}$ inch. There are two heavy internal lugs *a* for attaching the connecting-rod pin. One **V**-rib is used on top and two ribs *b*, views (*b*) and (*c*), under each lug to strengthen the connection between the lugs and the thin body. The lugs *a*, view (*a*), are cast solid, as is also the piston head *c*, so that the pin holes *d* and the three grooves *e* for the packing rings are produced by machining. The casting must be molded thick enough to allow $\frac{1}{8}$ inch all over the outside for finishing, except on the depressed, or undercut, areas *f* on the supports for the lugs *a*, which are not machined.

44. The general procedure in making the metal patterns and core boxes for the cast-iron piston, Fig. 22, is as follows: A wooden master pattern is made to produce the hollow aluminum working patterns. The form of the working patterns is such that they will make mold cavities conforming to the outside surfaces of the piston. The working patterns must also have a core print for the large interior core, and two core prints for the small side cores that form the undercuts in the outside surface around the ends of the lugs.

45. In addition to the multiple working patterns, a metal core box must be made for the large core that forms the inside surface, the open end, and the rectangular openings through the piston, and a separate box is needed to produce the

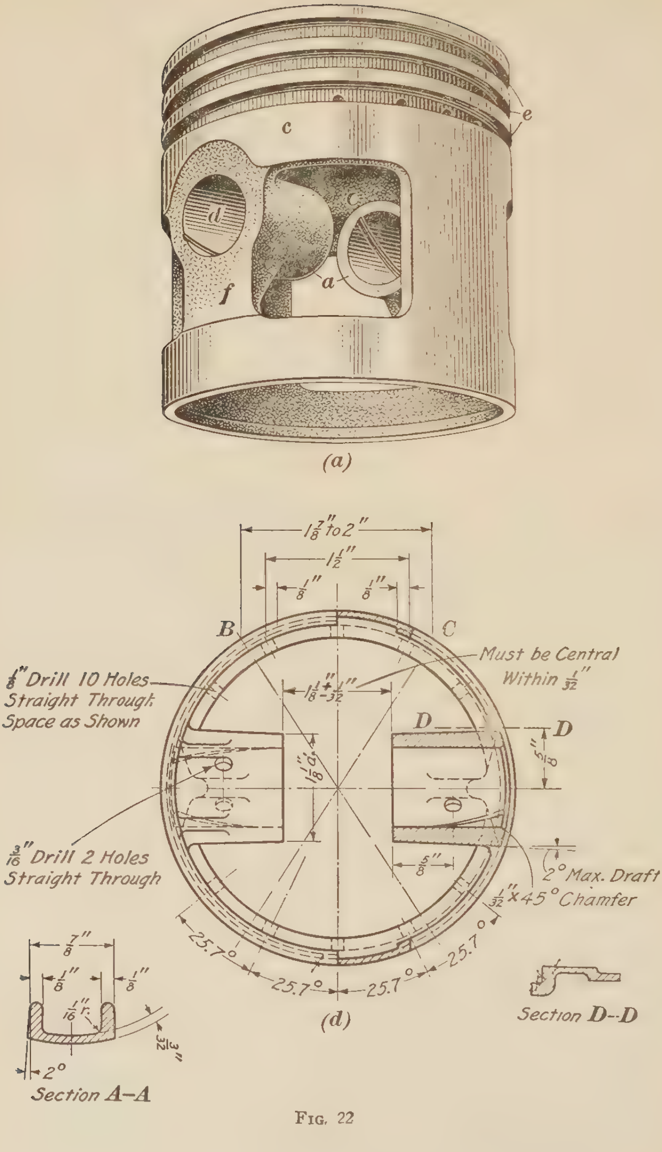

c
e
d
c
a
f
(a)
1 7/8" to 2"
1 1/2"
1/8"
1/8"
B
C
Must be Central Within 1/32"
1/8" Drill 10 Holes Straight Through Space as Shown
1 1/8" + 1/32" − 1/32"
D
D
5/8"
1 1/8" d.
3/16" Drill 2 Holes Straight Through
5/8"
2° Max. Draft
1/32" x 45° Chamfer
25.7°
25.7°
25.7°
25.7°
(d)
7/8"
1/8"
1/8"
1/16" r.
3/32"
2°
Section A–A
Section D--D

Fig. 22

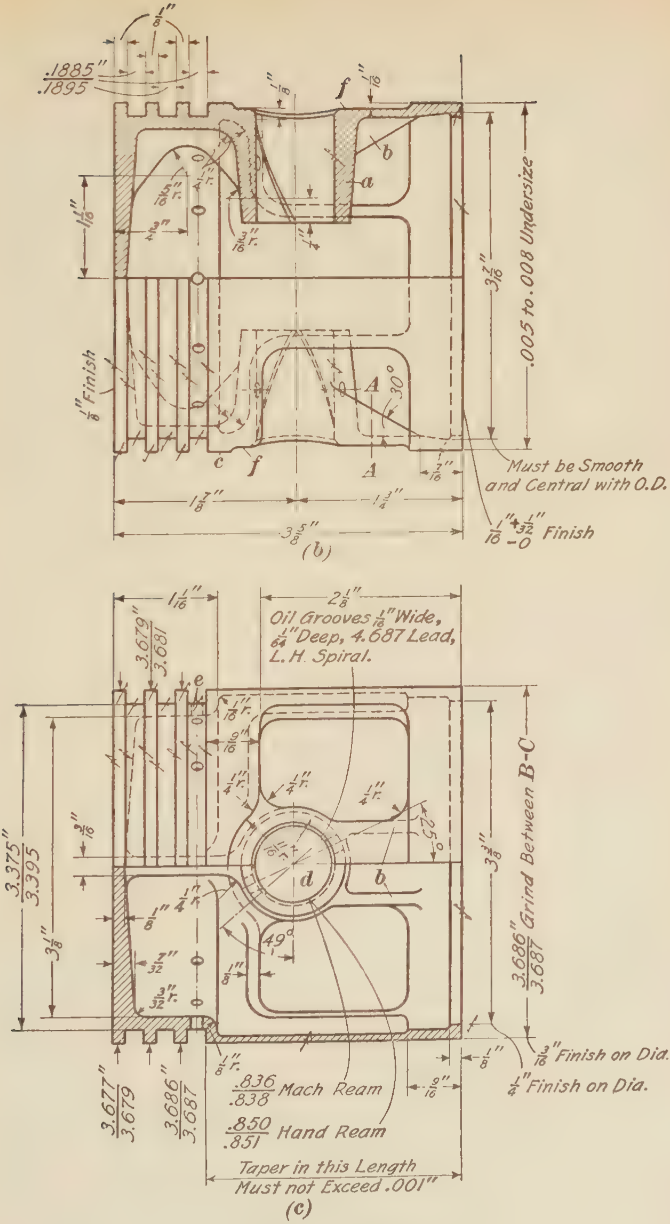


FIG. 22—(*Continued*)

small side cores. The details of the patterns and core boxes are given below.

46. Master Pattern for Piston.—The wooden master pattern for the piston, Fig. 22, is shown in Fig. 23 (*a*). Its body *a* is turned to the required outside dimensions and draft, and it is bored out to a thickness of about $\frac{1}{2}$ inch, with an inside draft of $\frac{1}{8}$ inch or more. The inside draft should be great enough to make a green-sand core that will draw freely from

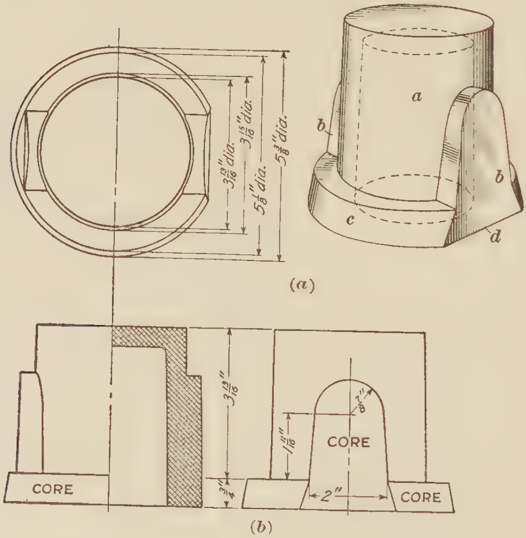


Fig. 23

the pattern. The purpose of the hollow master pattern is to produce similar shaped working patterns that will be as light as possible. A shrink allowance of $\frac{5}{32}$ inch per foot must be made on the master pattern for the aluminum working patterns, and an additional $\frac{1}{8}$ inch per foot for the cast-iron piston. Also, $\frac{1}{64}$ inch must be allowed on all surfaces of the master pattern that require turning or finishing on the metal working patterns. Furthermore, all surfaces of the piston casting that require finishing, as indicated on the mechanical drawing, Fig. 22, must have an allowance of $\frac{1}{8}$ inch of metal.

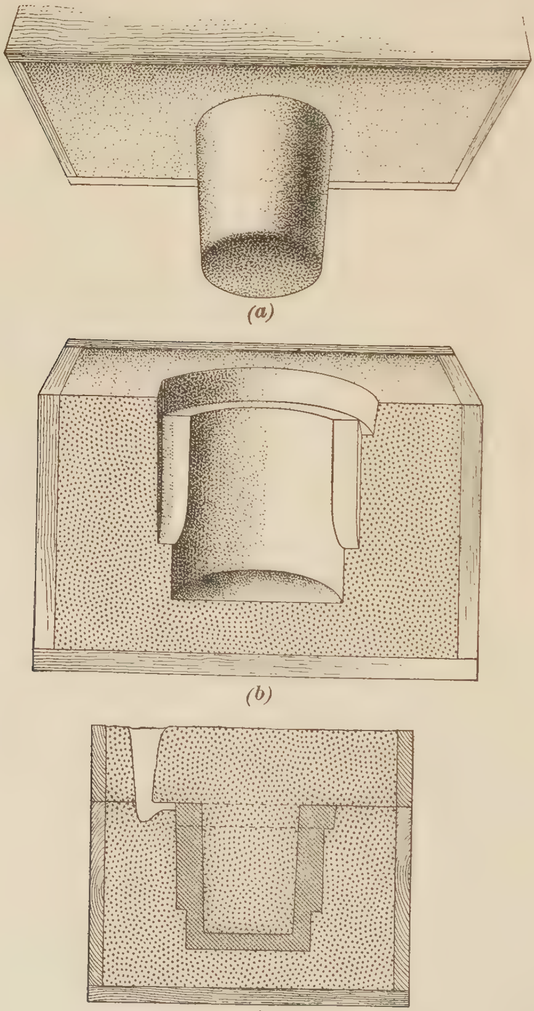
47. The master pattern, Fig. 23 (*a*), is fitted with two similar core prints *b* at the sides, and a large circular print *c* at the end. The side prints form the cavities in the mold to receive the cores used to make the undercuts *f*, Fig. 22, in the outside surface of the piston. The large end print *c*, Fig. 23 (*a*), forms a space in the mold to receive the dry-sand cover core that supports the inside core forming the hollow body. Considerable draft is given the large print *c*, as shown, in order that the cores may be centered in the green-sand molds made by the working patterns without disturbing the mold surfaces. The large core print *c* is cut away at one of the side core prints, as shown at *d*. This straight cut forms a gauge, or guide, in the mold cavity to receive a similar straight part on the dry-sand core, thus enabling the molder to assemble the molds easily and correctly.

48. Working Patterns for Piston.—The aluminum working patterns, Fig. 23 (*b*), for the piston, Fig. 22, have full allowances for draft, finish, and shrinkage, and are cast from the wooden master patterns, Fig. 23 (*a*), in the green-sand molds, Fig. 24. The cope is shown in view (*a*), the drag in (*b*), and the poured mold in (*c*).

The cylindrical and radial surfaces of the aluminum castings are finished on a lathe, and the other surfaces are hand finished by filing, scraping, and grinding. All surfaces of the working patterns should be polished as smooth as possible with emery cloth, and so that the grain of the finish will be lengthwise of the draw of the pattern. The large core print and the two side core prints should be stamped **CORE**, as shown in Fig. 23 (*b*), so that the molder will know what cores are used and where to place them.

49. Mounting Piston Working Patterns.—The method of mounting 6 working patterns on a 13″×18″ steel plate $\frac{1}{8}$ inch thick is shown in Fig. 25. These patterns may be placed quite close to the edges of the plate, because the large core print *a* on the end of the pattern forms a cavity that will be filled by a dry-sand core; thus there is no danger that the pressure from

the molten metal will break through the sides of the mold. The patterns are spaced and located by center lines and circles



(a)

(b)

(c)

Fig. 24

marked on the plate, so that they will be in two rows having the runner *b* between them, as shown. The gates *c* are at the open

end of the pistons and between the two outside core prints *e*. Three holes equally spaced are drilled through the plate on the central circle of the base of the patterns. One pattern at a time is clamped to the plate, and a drill is passed through the plate holes and deep enough into the patterns to be threaded with a $\frac{1}{4}$-inch 14×24 tap. Machine screws with their heads

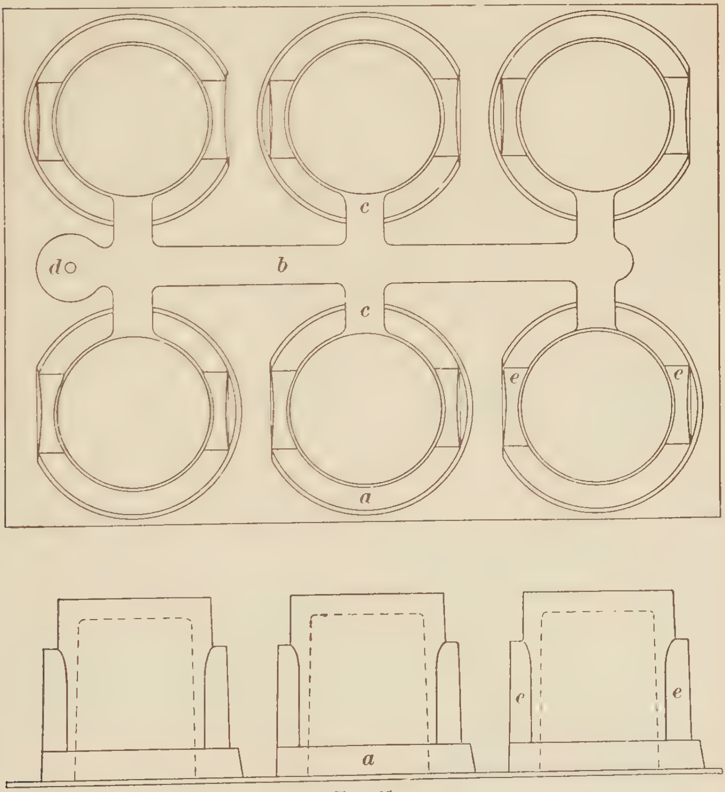


FIG. 25

countersunk are used to fasten the patterns to the plate. After the patterns have been attached to the plate by screws, two $\frac{1}{4}$-inch dowel-pin holes are drilled through the plate and into the bottom of each pattern. The dowels are driven in to prevent the patterns from moving and also to relocate them on the plate in case they are removed for repairs or changes.

50. Runner for Piston Patterns.—The runner *b*, Fig. 25, is cast of aluminum 1 inch wide and $\frac{3}{4}$ inch high. The connections *c*, or gates, are made 1 inch wide and $\frac{1}{4}$ inch high. The runner is fastened to the plate with flat-head machine screws, having their heads slightly countersunk below the surface of the plate. This plate of patterns makes the drag mold, Fig. 26. The cope is made on a flat plate having a hole drilled over the center of the runner boss *d*, Fig. 25, so that the sprue can be rammed up in the cope. A pin in the end of the sprue pattern engages the hole in the cope plate and thus locates the sprue correctly in the cope.

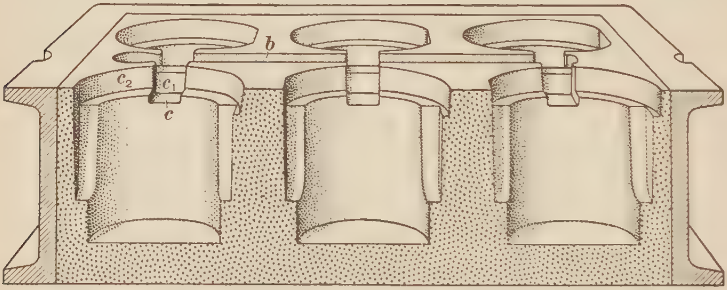


Fig. 26

The piston molds, Fig. 26, are shown ready to receive the cores. It will be seen that the connection between the runner *b* and the gate *c* entering the mold must be cut down at *c*, so as to pass around the edge of the large dry-sand core that is to be placed in the cavity c_2. A section of the assembled mold with the piston casting *a* is shown in Fig. 27. The two side cores *b* are set in place before the large core *c* so that the part *d* of the large core will hold down the cores *b*.

51. Core Box for Piston Side Cores.—Two metal core boxes are required for molding the piston shown in Fig. 22. One box is needed to make the large interior core *c*, Fig. 27, and its print *d*, and one to make the two small cores *b* that form the undercuts in the outside of the piston. As the outside cores are alike, they can be made in the same box. These cores have the same form as the core prints *b* shown on the master pat-

tern in Fig. 23 (*a*), and the dimensions of the prints are given on the working pattern, view (*b*). An additional feature of this core is its inner projection, which is shown at *f* in Fig. 27, and also in the master pattern, Fig. 28. The steps in making

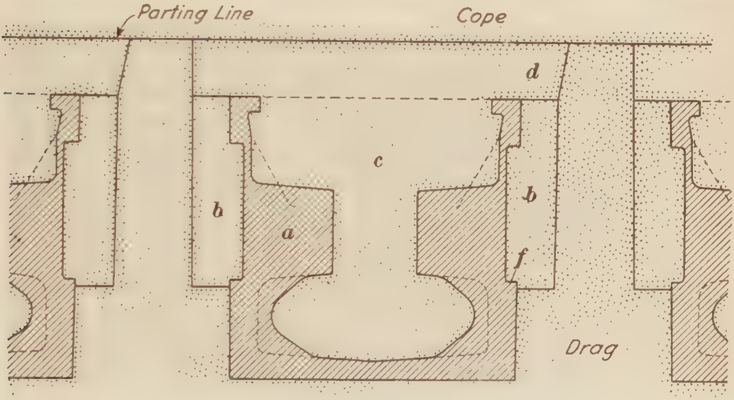


FIG. 27

aluminum core boxes for producing quantities of the outside cores at one time are as follows:

(1) Make a wooden master pattern, which is a block of the size and shape of the print made in the mold by the working pattern, and having an inner projection *f* dimensioned from the undercut shown in the drawing of the piston. Furthermore, the wooden pattern must have a shrinkage allowance of $\frac{3}{64}$ inch per foot for the white-metal working pattern to be cast from it, and $\frac{1}{8}$ inch per foot for the piston castings of cast iron. (2) Cast white-metal working patterns in sand molds from the wood pattern. File and sandpaper these to the correct size and finish. (3) Use the white metal working patterns to cast a plaster core-box pattern having a capacity for as many cores as desired.

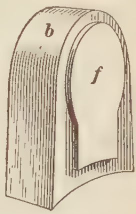
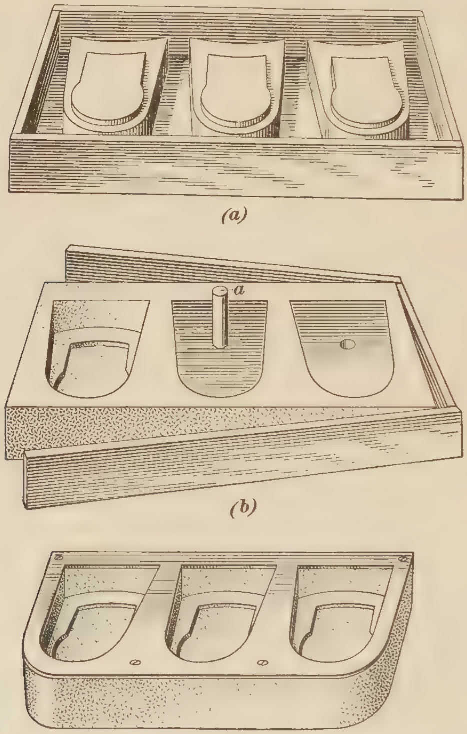


FIG. 28

52. A No. 30 hole is drilled in the center of each white-metal pattern for a draw hole. The patterns are then placed with their flat sides, or backs, on a surface plate, as in Fig. 29 (*a*), with a wooden frame around them. The depth

of the frame should be such that its top edge will be about $\frac{3}{8}$ inch above the highest point on the patterns. All the surfaces inside the frame are then covered with a thin coating of grease to keep the plaster from adhering to them, and the frame is poured full of plaster of Paris. When the plaster has



(c)
FIG. 29

set, it is turned over, as in view (*b*), and the metal core patterns are removed by driving a tapered wooden dowel pin *a* into the draw holes and striking each pattern lightly with a small hammer until it is free from the plaster. The wooden frame is removed by forcing its joints apart, and the block of plaster is cut to the required outside shape and dimensions of the aluminum core box. A draft of $\frac{1}{32}$ inch should be given to its sides and two thin coats of yellow shellac should be applied all over.

53. The last step (4) in making the finished core box for the outside cores of the piston, as shown in view (*c*), Fig. 29, is to cast an aluminum box from the plaster pattern, in a green-sand mold. The shrinkage of the aluminum will allow enough metal to be scraped and filed out of the cavities in the box to finish the core holes to the correct size. The face of the box should be machined off enough to allow the use of a steel cover plate $\frac{1}{16}$ inch or $\frac{1}{8}$ inch thick, which is fastened on by flat-head machine screws. The steel plate retains the correct outlines of the cores better than does soft aluminum.

54. Core Box for Inside Core of Piston.—The core *c* with its cover core *d*, Fig. 27, for the inside of the piston, is made in one piece in a two-part cylindrical box. A general view of

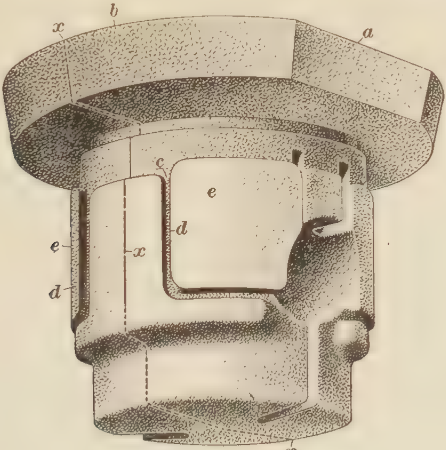
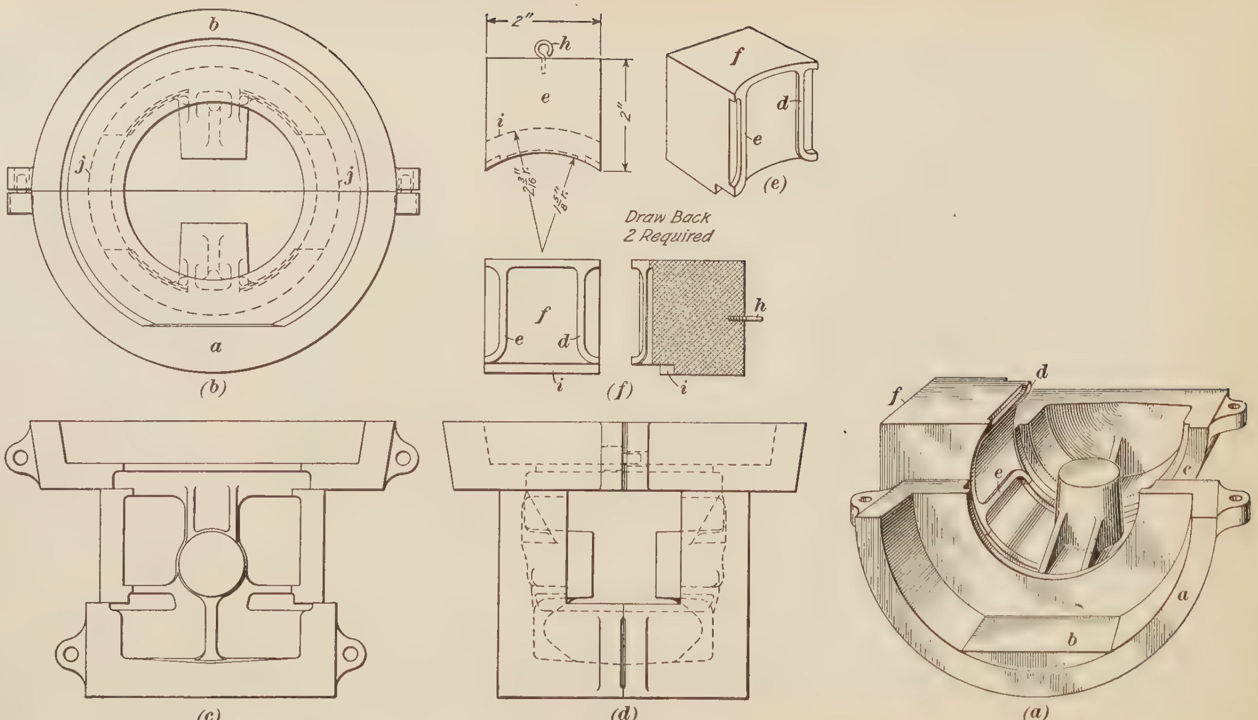


Fig. 30

the one-piece inside core is shown in Fig. 30. The mark of the parting line of the core box in which the core is formed is indicated by the dotted line *x-x-x*. Both halves of the core box, Fig. 31, are alike, except that the lower half *a* must have a straight part *b*, view (*a*), to form the flat *a*, view (*b*), in the core box. Furthermore, the ribs in the core box that form the grooves *c*, Fig. 30, lengthwise of the core will prevent the removal of the core-box halves from the core, because these



b
a
j
j
(b)
2"
h
e
i
2"
$2\frac{3}{16}$" r.
$1\frac{5}{8}$" r.
f
d
e
(e)
Draw Back
2 Required
f
e
d
i
h
i
(f)
f
d
e
c
a
b
(c)
(d)
(a)

FIG. 31

ribs are locked behind the edge *d* of the rectangular projections *c* on the body core. Therefore, these ribs must be made so that they can be drawn back from the core after the core has been rammed, thus making it possible to remove both halves of the box from the core. This construction is called a *draw back*.

55. The drawing of the inside core box, Fig. 31, is made from the inside dimensions of the piston as given on its drawing. A wooden pattern, view (*a*), is made for one half of the core box. Allowance must be made for two shrinkages of $\frac{5}{32}$ inch per foot for the aluminum core-box casting, and $\frac{1}{8}$ inch per foot for the cast-iron piston castings. Also an allowance of $\frac{1}{16}$ inch should be made for the finishing of all surfaces in the aluminum core box. Where finish marks are noted on the face of the core box, $\frac{1}{8}$ inch is added for machining. The core print dimensions must be taken from those on the mounted working patterns. The part *a* of the half pattern is made for the complete semicircle of the large core print, and the required number of aluminum castings are made from it. Then the flat-sided piece, or core setting guide, *b*, view (*a*), is attached to the pattern and the same number of castings are again made from the pattern. After all the castings are scraped, filed, and machined, they are paired for the complete core boxes by putting a casting having a core guide *b* with one without the guide, as shown in view (*b*) at *a* and *b*, respectively.

56. It will be seen that each half box has two notches or missing areas indicated at *c*, Fig. 31 (*a*), and by lines on the parting surfaces of the other views. These notches are the parts of the box that are to be occupied by the draw backs *f*, which are used to permit the removal of the ribs *d* and *e*, views (*a*) and (*e*), from the core and to make it possible to take the core-box halves from the core. The draw back extends an equal distance into both halves of the box. Details of the draw back are given in views (*e*) and (*f*). The two draw backs, one for each side of the core box, are cast of aluminum from a wooden pattern. The castings are finished to size and a steel hook *h* is screwed into the back of each, the

hooks being used to draw the parts back from the rammed core. A steel rod applied to the hooks may be used to move the draw backs. A circular groove *i* in one end of the draw back is made to fit the outside circumference of the box at *j*,

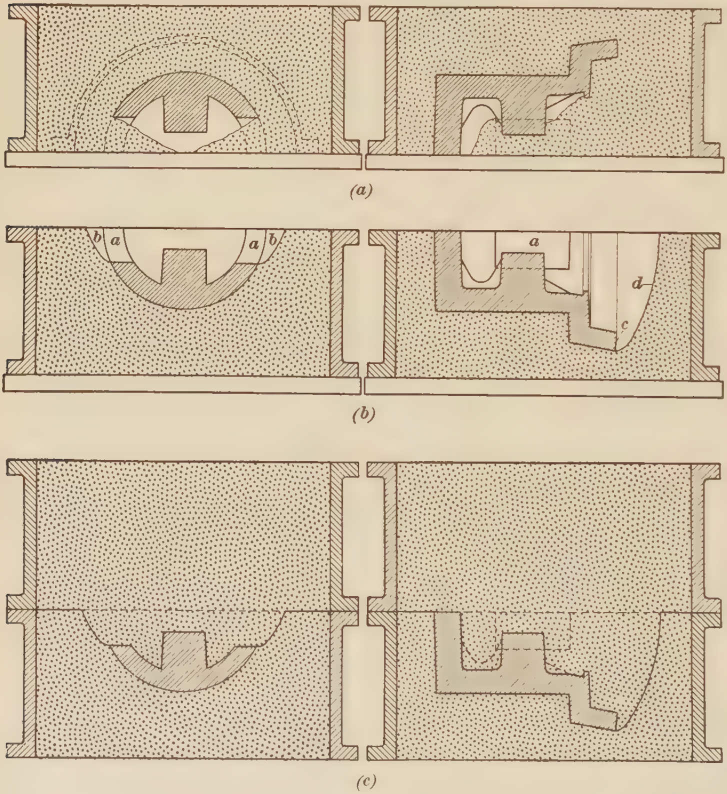


Fig 32

view (*b*), and acts as a stop to limit the inward movement of the draw back.

The core boxes are usually mounted on $\frac{3}{8}$-inch steel plates fastened to the small ends of the boxes by the use of flat-head machine screws. One plate is used for each row of half core boxes, so that all the halves may be separated at one time after all the boxes have been rammed with the core material. The

boxes must be spaced at least $\frac{3}{8}$ inch apart in order that the draw backs may be removed from between them.

57. Molding Core Boxes for Piston.—Details of one method of molding the aluminum half core boxes from the wooden master pattern, Fig. 31 (*a*), are shown in Fig. 32. The outside of the half pattern is rammed up as in view (*a*); the box is then turned over, as in view (*b*). The openings *a* for the draw backs are cut out of the sand, and the partings *b* are made;

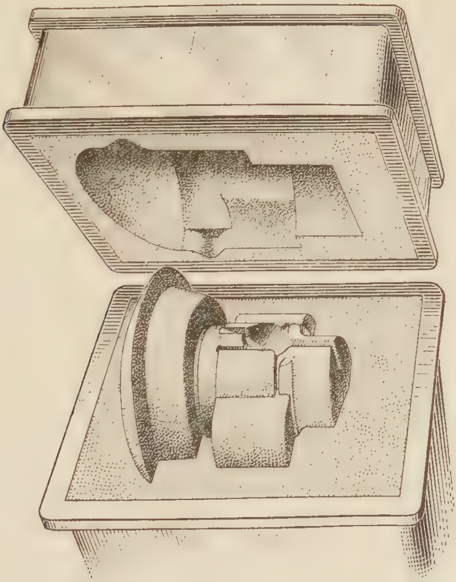


Fig. 33

also the mold is cut out to expose the surface of the large end *c* of the pattern and a suitable parting is made, as at *d*. The inside of the pattern is then rammed up as shown in view (*c*). The finished mold is shown in Fig. 33.

FRAME-MOUNTED METAL PATTERNS

58. Method of Mounting Metal Patterns in Frames. Metal patterns that cannot be conveniently mounted on a plate are gated, or carded, and mounted in a frame which is used on

a molding machine. High production of castings can be obtained by frame mounting, as well as by plate mounting, and either a single metal pattern or a gate of patterns may be used.

For frame mounting, a fixture is first made that can be used on a molding machine, which is usually of the squeezer type. Such a fixture is shown in Fig. 34 and is made of cast hard yellow brass from a white-metal pattern. In the case here shown, the size of the flask to be used for molding a certain

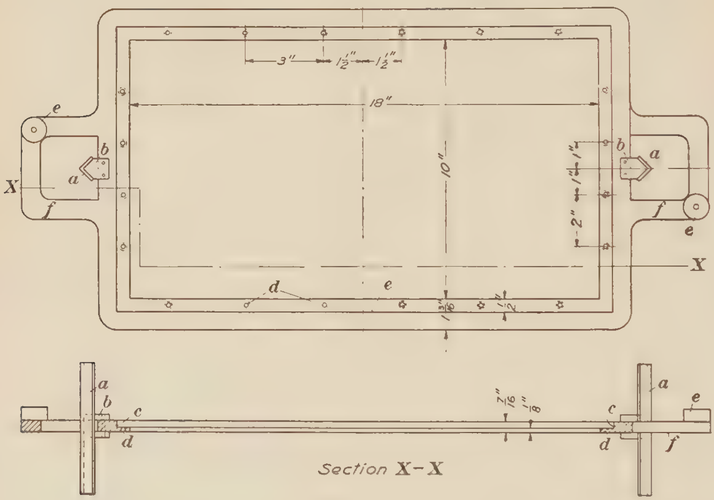


FIG. 34

casting is 10 inches by 18 inches. The fixture is made so that the pins *a* will fit the pins in the flask. These pins are made of ⅝-inch angle iron 5 inches long. All burrs and scale on the fixture pins are removed by grinding the outside faces on a disk grinder and filing the inside faces of the flask pins. The angle iron is welded or riveted to a block *b* made of cold-rolled steel, and the whole is riveted to the fixture with two ¼-inch-diameter steel rivets.

59. The recess *c*, Fig. 34, is machined to size on a milling machine, and a No. 9 drill is used to drill the holes *d*. These holes are countersunk on the back of the fixture for No. 10-32 flat-head machine screws. The distance between the holes *d*

at the end of the fixture is 2 inches, and the distance between the holes on the side of the fixture is 3 inches. The purpose of the bosses *e* on the handles *f* at each end of the fixture is to enable a vibrator to be mounted, which is used to rap, or jar, the patterns while they are being drawn from the mold. The bosses are 1 inch in diameter and are finished to a thickness of $\frac{1}{2}$ inch, the width of the slot in the vibrator used on a 10″×18″ flask. A hole $\frac{5}{16}$ inch in diameter is drilled in the center of each boss for the bolt that fastens the vibrator to the fixture. Although only one vibrator is used at one time, two bosses are usually cast on the fixture, so that the vibrator can be used at either end.

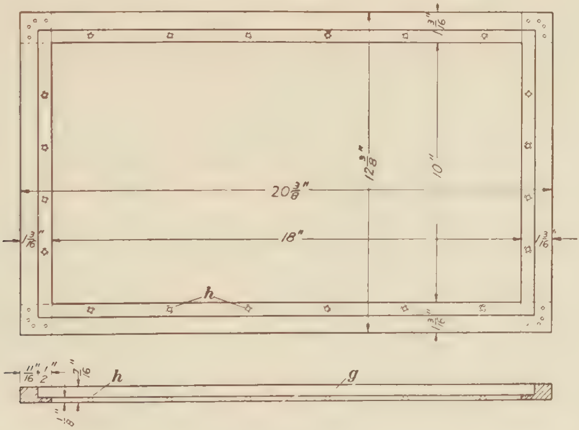


FIG. 35

60. The fixture, Fig. 34, is next straightened on a surface plate with a rawhide mallet and filed smooth with a mill file. The handles of the fixture are made especially smooth with all corners carefully rounded over to prevent injury to the hands of the molder. The fixture is mounted on a surface plate on two steel parallels 3 inches high and 21 inches long, in order to ascertain whether the pins on the fixture are exactly at right angles to the surface plate, which fact can be checked with a 12-inch square. This test must be made very accurately, because if the pins are out of true the pattern cannot be drawn from the sand without spoiling the mold.

61. Construction of Pattern Frame.—To hold the patterns on the fixture described in connection with Fig. 34, a frame is made on which the gate of patterns may be mounted. One form of pattern frame is shown in Fig. 35. It is made of

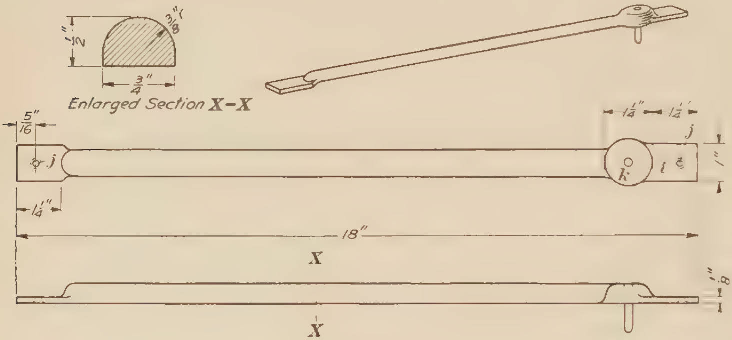


FIG. 36

four bars of cold-rolled steel having a cross-section of $\frac{7}{16} \times 1\frac{3}{16}$ inches. Two of the bars are $20\frac{3}{8}$ inches long and the other two $12\frac{3}{8}$ inches long. The recess *g* is made to size on a milling machine, the milling cutter being stopped $1\frac{3}{16}$ inches from each end to allow enough stock to make a splice joint. The long bars are milled down at the side of the recess, and the short bars from the flat side. The ends of each bar are milled down to half the thickness, or $\frac{7}{32}$ inch, for a distance of $1\frac{3}{16}$ inches from each end.

The four bars are soldered together, care being taken to make the frame perfectly square and to maintain the inside size $10'' \times 18''$. Six holes *h* are drilled 3 inches apart in the long sides of the frame and four holes 2 inches apart in the short sides, exactly similar to the manner of drilling the holes *d* in the fixture, Fig. 34. The holes are countersunk on the back, or cope, side of the pattern frame to receive No. 10-32 flat-head machine screws. The frame is straightened, all burrs and sharp edges are removed with a mill file, and is kept in the stockroom of the patternshop for use with all $10'' \times 18''$ gates of patterns that fit in the fixture used in the molding machine.

62. Making Runner for Pattern Frame.—The runner for a 10″×18″ molding machine pattern frame is shown in Fig. 36. It is made of cast brass from a metal pattern. The length of the runner is 18 inches, the width is $\frac{3}{4}$ inch, and the thickness $\frac{1}{2}$ inch. The dimensions of the width and thickness of the runner here given are generally used on runners for medium-sized castings of brass and other alloys. The end lugs *i* of the runner are cast $\frac{3}{16}$ inch thick and are machined on a milling machine to a thickness of $\frac{1}{8}$ inch for a distance of $1\frac{1}{4}$ inches from the ends. Holes *j* are drilled on the center line of the end lugs with a No. 20 drill, the distance of the center of each hole to the end of the lug being $\frac{5}{16}$ inch. The holes are then tapped with a No. 10-32 tap. The boss *k* indicates the place where the sprue is located on the runner for pouring the mold, and a $\frac{1}{4}$-inch diameter drive-fit hole is drilled in the center of the boss for the purpose of inserting the pin that receives the sprue pattern. The runner is filed smooth with a mill file and then

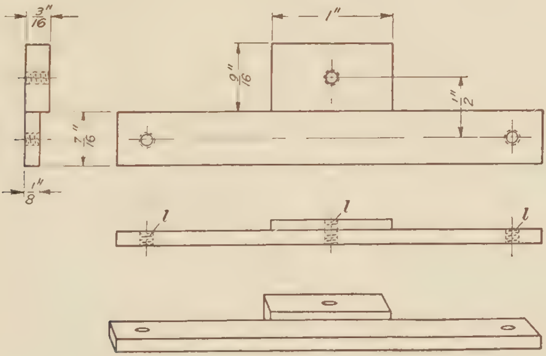


Fig. 37

sandpapered with No. 0 sandpaper, after which it is straightened on a face plate with a rawhide mallet. A number of runner castings are kept in stock in the patternshop for use when needed.

63. A connection must be made to hold the runner, Fig. 36, in the frame. This connection is shown in Fig. 37. It is made of cast brass, roughly finished with a flat bastard file.

Two castings are made according to the dimensions on the drawing, and the holes *l* in each are drilled by using a tool-steel jig, as shown in Fig. 38. The recess *m* in the jig is milled out as far as possible and the remaining metal is chipped

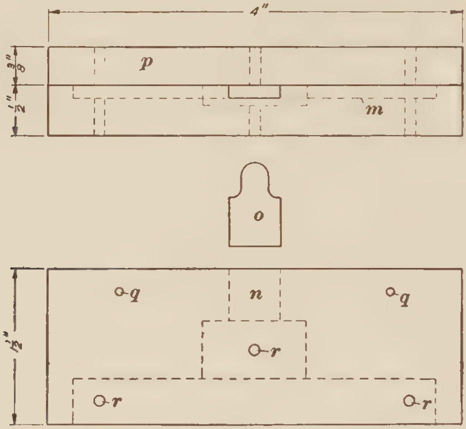


Fig. 38

out with a small cold chisel. A slot *n* ⅛ inch deep and ½ inch wide is made in the jig to fit a punch *o* which is used to force the casting of the runner connection out of the jig after it has been drilled. The upper part *p* of the jig consists of a flat piece of steel ⅜ inch thick, 1½ inches wide, and 4 inches long, and is riveted to the lower part by the rivets *q*. The jig is hardened by heating it to a cherry red and quenching it in cold water or oil. The connection casting is inserted in the recess in the jig and held in place by use of a small **C** clamp. A No. 20 drill is run through the holes *r* in the jig and also through the connection casting after which the casting is removed from the jig, and the holes are tapped with a No. 10-32 tap. A number of connection castings are always kept in stock in the pattern shop for use when needed. The advantage of using jigs for drilling the holes in metal patterns is that the jigs make the parts alike and thus interchangeable.

64. Mounting Gate of Patterns in Frame.—Suppose that it is required to mount a gate of patterns for the oilhole cover

shown in Fig. 39, and afterwards to mount the gate in a molding machine frame, a 10″×18″ flask being used. Only two patterns can be used to make up the gate of patterns that can be mounted in a frame for a 10″×18″ flask. The cover is cast in brass, and all dimensions are to be held closely to those given on the working drawing, as no machining is to be done on the casting, and it must fit an oilhole in a bearing casting to which it is held by a bolt passing through the hole *a* in the center. A wooden master pattern is made with double

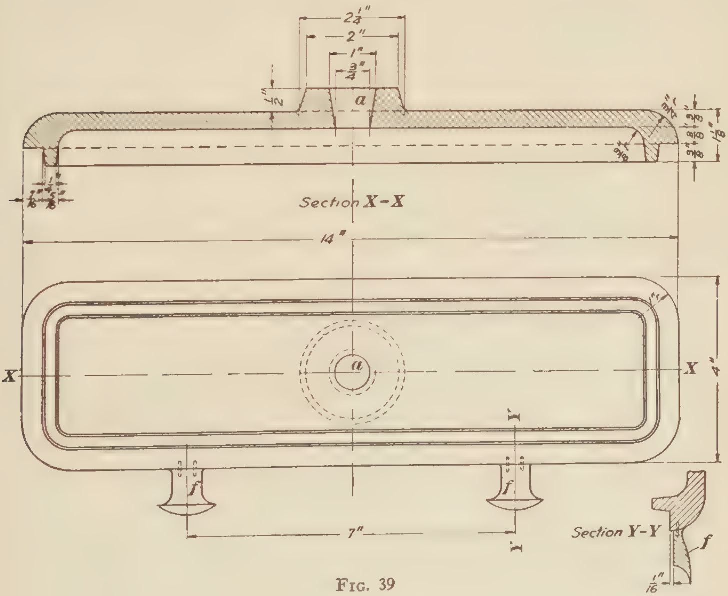
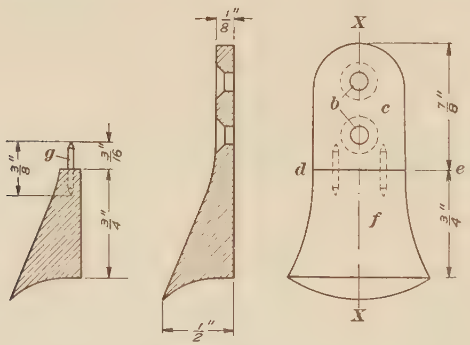


Fig. 39

shrink; that is, with a shrink of $\frac{3}{64}$ inch per foot for the metal working pattern and a shrink of $\frac{3}{16}$ inch per foot for the brass casting.

65. To make the connections between the patterns and the runner, four brass castings as shown in Fig. 40 are made from a metal pattern. The countersunk holes *b* are cast direct from the pattern. The castings are filed smooth with a half-round mill file and the end *c* is tinned as far as the line *de* by dipping the castings first in soldering acid and then in a ladle of molten

solder. The excess solder is removed with a brush while the casting is still hot. Two of the castings are sawed off at the line *de* and two holes are drilled in the ends of the pieces *f* with a No. 41 drill. A No. 40 brass rod about ½ inch long is driven into each hole so that ¼ inch of the brass rod projects outside the piece as shown at *g*. The projecting rods are filed to a point and the two pieces *f* are driven into the master pat-



Section *X–X*

FIG. 40

tern as shown in Fig. 39. Care must be taken to leave $\frac{1}{16}$ inch between the face of the print and the cope side of the pattern as shown in the section *Y-Y* taken through the print *f*.

66. A wax-filler fillet is formed around the prints *f*, Fig. 39, at the junction with the patterns by use of a hot soldering copper. The four castings that were tinned are laid in the depressions in the sand made by the prints on the master pattern, and two white metal castings are made of the master pattern. The metal in filling the mold surrounds the castings and flows through the countersunk holes *b*, Fig. 40, thereby fusing fast to the tinned surfaces. The white metal castings are then checked for accuracy of their dimensions which should be about .010 inch over the dimensions indicated on the drawing as measured with a $\frac{3}{16}$ inch per foot shrink rule, to allow for filing, scraping, and sandpapering. The patterns are filed on the outside with a flat solder file and on the inside they are scraped with a three-

cornered scraper, to remove the rough spots and any scale that may be present.

67. The taper hole *a* in the pattern of the cover shown in Fig. 39 is next finished in a drill press by use of a tapered reamer. When the hole is very nearly the correct size a little machine oil is used on the reamer to produce a very fine finish on the sides of the hole. The patterns are then sandpapered with No. 00 sandpaper, care being taken to sandpaper the hole so the scratches are in the same direction as the draft. This is done by wrapping a 6-inch half-round file with No. 00 sandpaper and moving the file in the hole with an up-and-down

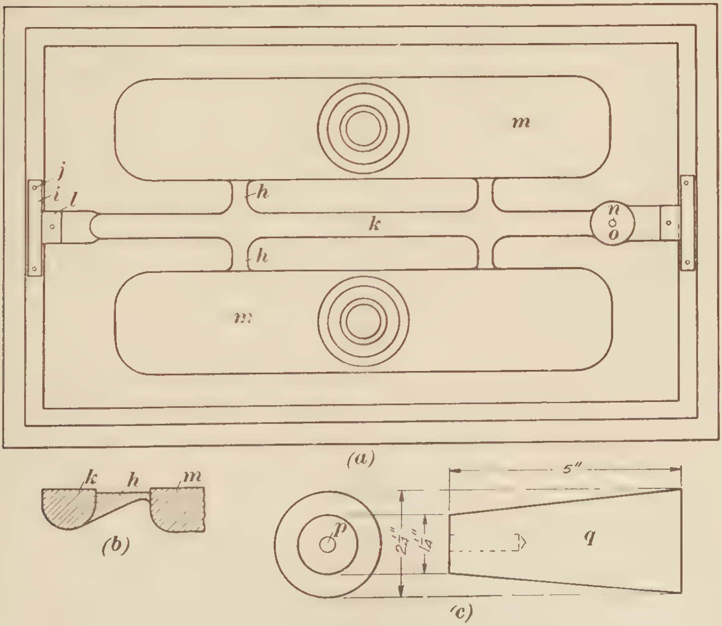


Fig. 41

motion, keeping the sides of the hole perfectly straight. If the sides are humped or the edges of the hole rounded, a back draft may be produced which may break off the sand core in the mold.

68. The finished white-metal patterns of the cover, Fig. 39, are next laid on a surface plate with the rib side down and the pattern connections *h* opposite each other, as shown in Fig. 41 (*a*), which shows the drag side of the frame. Two runner connections *i* are fastened in the ends of the frame with two No. 10-32 flat-head machine screws *j*, the runner *k* being in turn fastened to the runner connection lug *l* by a 10-32 flat-head machine screw at each end. The runner is placed between the two patterns *m* in such a way that the pattern connections *h* just touch the runner. In placing the flat, or cope, side of the frame on the surface plate, the frame is raised on parallels until the flat side of the runner *k* is level with the flat, or bottom, side of the pattern *m*, as shown in view (*b*). The runner and connections are then soldered together with a large soldering copper by putting soldering acid on the joints and holding the copper on the joints until the solder sweats through. The surface plate is protected against the action of the soldering acid by putting a piece of paper between the plate and the frame and patterns.

69. The gate of patterns consisting of the two patterns *m*, Fig. 41 (*a*), the runner *k* and the pattern connections *h* is disconnected from the frame by removing the four screws *j*, and thoroughly washed in water to remove all traces of the soldering acid. The excess solder is removed from the joints with a half-round solder file, and the joints are smoothed with No. 0 sandpaper. A brass rod $\frac{1}{4}$ inch in diameter and 2 inches long is driven into the hole *n* in the center of the boss *o* on the runner, to act as a pin, which is later fitted into a $\frac{5}{16}$-inch hole *p*, view (*c*), in the end of the sprue pattern *q* when the cope part of the mold is being made. Finally, the gate of patterns is connected to the fixture by inserting the screws *l*, view (*a*), in the runner connections *i* after which the frame is ready for use in the molding machine.

INTERCHANGEABLE PATTERN-PLATE MOUNTING

70. Fixture for Interchangeable Pattern Plates.—Interchangeable pattern plates permit the use of a number of different pattern plates in the same flask without fastening the plates

together permanently. This can be done by using a molding machine fixture that will hold several pattern plates, the number depending on the size of flask to be used. The pattern plates can be interchanged in the fixture as often as desired. A fixture in which a number of interchangeable pattern plates can be mounted is shown in Fig. 42. It is cast in hard yellow brass from a metal pattern. As the pattern is a thin one, a metal pattern is preferable to a wooden pattern, which would warp in a short time.

71. The fixture shown in Fig. 42 is made to fit a 10″×18″ flask. It is first straightened on a face plate, and all rough

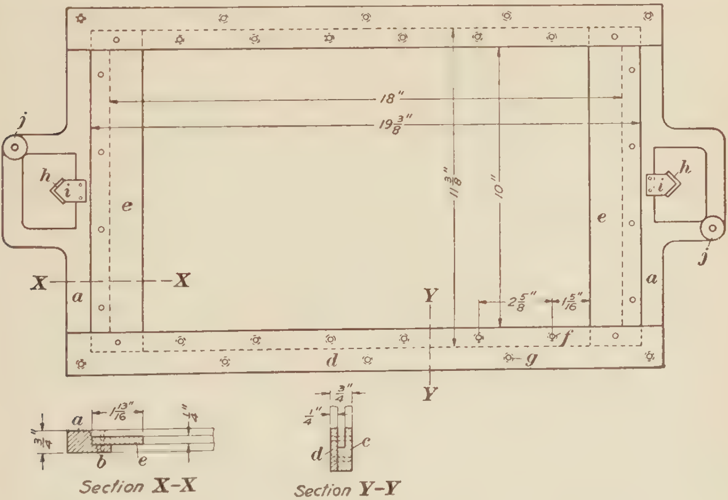


Fig. 42

spots and imperfections are removed with a flat mill file. The short end bars *a* of the fixture are first milled down as shown in the section *X-X*, to form the short sides of a recess *b* in the fixture. The long side bars *c* of the fixture are milled down as shown in the section *Y-Y*, to form the long sides of the recess. The height of the bars *c* is milled $\frac{1}{4}$ inch lower than the height of the bars *a* so that a strip of cold rolled steel *d*, $\frac{1}{4}$ inch thick, $1\frac{1}{2}$ inches wide, and 21 inches long may be fitted on each of the bars *c* in order to make the top of the bars *c* flush with the bars *a*.

The recess *b* formed in the sides of the fixture then has a length of $19\frac{3}{8}$ inches, a width of $11\frac{3}{8}$ inches, and a depth of $\frac{1}{2}$ inch. Two sheet brass fillers *c*, $\frac{1}{4}$ inch thick, $1\frac{13}{16}$ inches wide and $11\frac{3}{8}$ inches long are riveted permanently to the ends of the fixture. Their object is to hold the pattern plates away from the ends of the fixture.

72. Each of the strips *d*, Fig. 42, has a number of holes drilled in it with a No. 1 drill and these are countersunk for No. 12-24 flat-head machine screws. The inside row of holes *f* through the recess *b* are for the screws that hold the pattern plates in the fixture, and are drilled with the outside centers a distance of $1\frac{5}{16}$ inches from the edges of the fillers *c*, the inside centers being $2\frac{5}{8}$ inches apart. These dimensions are standard so that different pattern plates can be used in the fixture. The outside holes *g* are for the screws that hold the strips *d* on the fixture. A draft of $\frac{1}{32}$ inch is filed on the inside edges of the strips *d* and of the fixture to enable the sand to draw away from the pattern plates without breaking.

73. The steel strips *d*, Fig. 42, serve to clamp the pattern plates in the fixture after the plates have been fastened in the recess with screws, the additional reinforcement being made necessary owing to the weak nature of the pattern plate material. At the ends of the fixture are two pins *h* made of $\frac{5}{8}$-inch angle iron and 5 inches long, welded or riveted to a cold-rolled steel block *i*, which is riveted to the fixture with two steel rivets. The vibrator bosses *j* are 1 inch in diameter and $\frac{1}{2}$ inch thick, and have a hole $\frac{5}{16}$ inch in diameter in the center for the bolt that fastens the vibrator to the fixture. In order to provide a space in the mold to place the sprue, a plate of sheet brass $\frac{1}{4}$ inch thick, $2\frac{3}{8}$ inches wide, and $11\frac{3}{8}$ inches long is placed in the mold on either end of the fixture.

74. Use of Two Pattern Plates In One Fixture.—Let it be required to use the fixture just described for two pattern plates, one $7\frac{7}{8}$ inches wide and the other $5\frac{1}{4}$ inches wide. Both must be $11\frac{3}{8}$ inches long, as they must fit in the recess of the fixture, which is $11\frac{3}{8}$ inches wide. The large plate has a set of white-metal patterns mounted on it which are duplicates of the pattern

of the cast-iron wing nut shown in Fig. 43 (*a*), and the small plate carries a set of duplicate patterns of the cast-iron ratchet stop shown in view (*b*). To make the working patterns of the wing nut, a wooden master pattern of the nut is first made. This master pattern has a double shrink, a shrink of $\frac{3}{64}$ inch per foot for the white-metal working patterns, and a shrink of $\frac{1}{8}$ inch per foot for the iron casting. The parting line on the pattern shown in view (*a*), is the line *W-W*, and on the pattern shown in (*b*) it is the line *Y-Y*, which necessitates a draft on the patterns as shown at *k*. The amount of draft is $\frac{1}{32}$ inch.

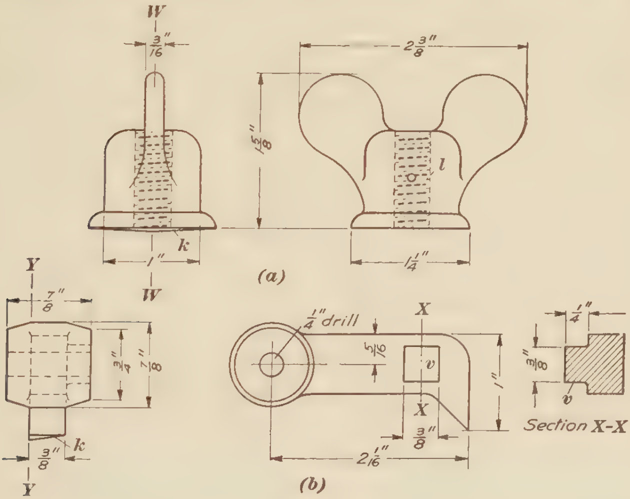


FIG. 43

75. The dimensions of the large pattern plate are such that six working patterns can be mounted on it. In making the white-metal working patterns, it is allowable to make the dimensions of the wing nut, Fig. 43 (*a*), within $\frac{1}{64}$ inch of the size indicated on the drawing, as the nature of the casting does not call for extremely accurate dimensions. The white-metal castings are roughly filed off with a half-round and a flat solder file, and are then finished with No. 0 sandpaper. A hole *l*, made through each pattern with a No. 20 drill serves as a drawhole, the pattern being drawn from the sand by means of a sharpened wooden dowel driven into the drawhole.

76. Casting Frames.—A frame known as a casting frame is made for each of the two pattern plates that are to be mounted in the fixture shown in Fig. 42. The casting frame is made of steel and is laid between the cope and the drag of the mold in which the plate is made. The thickness of the frame is made the same as that of the plate, or in this case $\frac{1}{4}$ inch. The width and length of the casting frame depend on the width and length of each pattern plate. The object of the casting frame is to allow the molten metal, flowing in the mold, to fill the casting frame, thereby making a plate $\frac{1}{4}$ inch thick having the copes of the working patterns on one side and the drags on the other.

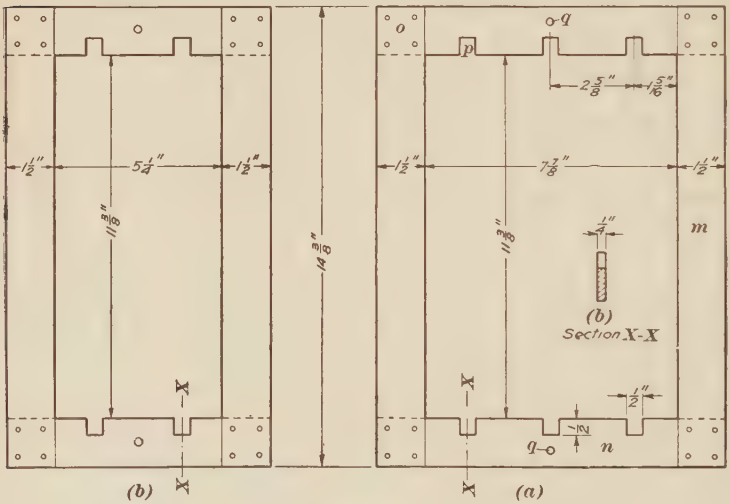


Fig. 44

77. The construction of the casting frame for the larger of the two pattern plates is as follows: Two bars *m*, Fig. 44 (*a*), of cold rolled steel $\frac{1}{4}$ inch thick and $1\frac{1}{2}$ inches wide are made $14\frac{3}{8}$ inches long, and two bars *n*, of the same thickness and width, are made $10\frac{7}{8}$ inches long. The ends of each bar are milled down to a thickness of $\frac{1}{8}$ inch for a distance of $1\frac{1}{2}$ inches so as to provide for a splice joint, as shown at *o*. Three slots *p* $\frac{1}{2}$ inch wide and $\frac{1}{2}$ inch long are sawed and filed into each of the short bars *n* of the frame, after which all burrs and sharp edges

are removed by filing, and the bars are straightened on a surface plate and soldered together into a rectangular frame. Four holes are drilled at each spliced corner with a No. 12 drill, and $\frac{3}{16}$-inch rivets used in the holes to strengthen the frame. The rivets and surplus solder are filed flush with the frame, and two drawholes q are drilled in the bars n with a No. 20 drill. The inside dimensions of the frame so formed show a width of $7\frac{1}{8}$ inches and a length of $11\frac{3}{8}$ inches, and allow the pattern plate to be fitted inside of the frame.

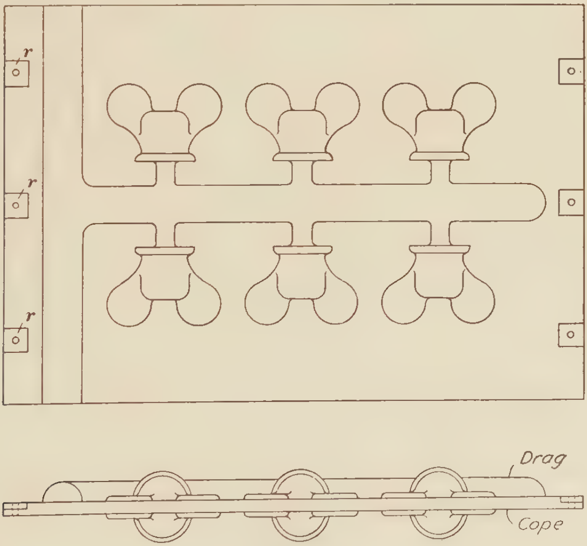


FIG. 45

78. A casting frame similar to the one just described is made for the small pattern plate that is to be mounted in the fixture; this frame is shown in Fig. 44 (b). The inside width of the frame is made $5\frac{1}{4}$ inches to correspond with the width of the smaller pattern plate, and the length is $11\frac{3}{8}$ inches, the same as that of the frame for the larger pattern plate. Two $\frac{1}{2}$-inch slots are made in the short bars of the frame as against three slots made in the corresponding bars of the larger casting frame.

79. Next, a sand mold is made of the six working patterns of the wing nut shown in Fig. 43 (a), the patterns being placed

in the mold exactly as they are to be mounted on the pattern plate. The position of the patterns is shown in Fig. 45. The casting frame for this pattern plate is laid on the bottom or follow board of the mold, and the patterns and runner are placed in position before the mold is rammed up. The casting frame is then removed and the mold rammed up. The runner pattern is made of white metal and is used on all the cast pattern plates of the same size. To keep the runners on both pattern plates properly alined as the plates are assembled in the fixture, a standard distance of $1\frac{7}{16}$ inches is provided from the inside edge of each plate as it is cast, to the edge of the runner.

80. Care must be used to keep the sand in the mold on which the casting frame is laid as level as possible. The casting frame is next placed on the drag half of the mold so as to make the pattern plate as shown in Fig. 45. The six patterns are drawn from the sand of the drag, care being taken to mark each pattern and its location in the mold so that it will be possible later to return the patterns to their proper places in the mold. Holes are drilled in the cope side of the patterns with a No. 20 drill at three places evenly distributed over the face of the patterns and tapped with a No. 10-32 tap, after which three No. 10-32 flat-head machine screws $\frac{1}{2}$ inch long, that have previously been tinned, are screwed into the patterns until the heads of the screws project $\frac{3}{16}$ inch outside the face of the patterns. The runner patterns are next removed from the mold, and the patterns are replaced in their proper locations in the mold with the tinned screw heads facing up.

81. Locating Pattern Plate on Molding-Machine Fixture. To locate the pattern plates on the fixture, steel inserts *r*, Fig. 45, are cast in the plates. These inserts are afterwards drilled in a jig and tapped, so that the pattern plates can be fastened in the fixture by screws. The inserts are made of cold-rolled steel $\frac{1}{8}$ inch thick and $\frac{1}{2}$ inch wide. Six pieces, each $1\frac{1}{4}$ inches long, are sawed off with a hack saw for use on the larger plate, and four pieces, of the same length, for the smaller plate. These pieces are tinned by dipping them first in soldering acid and then in molten solder. The excess solder is removed with a brush

while the steel is still hot, after which the inserts are laid in the slots in the casting frame on the drag which will allow $\frac{1}{8}$ inch of white metal to cover them.

82. The cope half of the mold is now closed over the casting frame and the drag halt. The casting frame holds the cope and the drag halves of the mold $\frac{1}{4}$ inch apart, and the space between the two and the outside of the frame is filled with wet sand or clay. This is called *mudding up*, and prevents the metal from running out of the mold at any places where the casting frame may not rest tightly against the sand. In closing the mold, care must be taken not to crush the casting frame into the mold surfaces. The frame is only $1\frac{1}{2}$ inches wide, and as it is the surface of this frame that holds the halves of the mold apart, the frame is easily crushed into the sand; therefore, the cope should be set as lightly as possible. The sprue must be placed inside the casting frame, as otherwise it would not permit the metal to feed the casting. After the mold is poured and has become cool, the casting frame is removed. The sprue may be melted off by the application of the edge of a hot steel bar against the side of the sprue close to the casting. This bar should be about $\frac{1}{4}$ inch thick, 2 inches wide, and long enough to be handled safely when one end is heated red hot. The heated end of the bar should be bent to a radius of about 4 inches for a short distance, so that the sprue can be cleaned off very close to the plate by the curved end of the bar and the surface of the plate be left smooth.

83. The plate casting so obtained is first checked for thickness, which must be exactly $\frac{1}{4}$ inch all over. If the plate is not of uniform thickness, but is thin on one side, the castings made of it will have a fin on the parting, and if the plate is thick on one side, the mold will crush and indentations will appear at the parting on the castings. The high and the rough spots are removed by filing and scraping. This must be done carefully so as not to remove a high spot on the cope that is opposite a low spot on the drag side of the plate, thereby making the plate too thin. The steel inserts projecting from the ends of the plate are sawed off flush with the end of the plate.

84. The next step is to place the pattern plate in the drilling jig shown in Fig. 46 (*a*) in order to drill the holes in the inserts on the ends of the plates for the screws that hold the plate in the fixture. The jig consists of a frame made of cold-rolled steel bars 1 inch wide and $\frac{1}{4}$ inch thick, and the construction is similar to that of the casting frame for the plate. The inside dimensions of the jig frame are exactly the same as the outside dimensions of the pattern plate, or $7\frac{7}{8}$ inches wide and $11\frac{3}{8}$ inches long. The drill guides *s* are made of tool steel and are $\frac{3}{8}$ inch thick, $\frac{1}{2}$ inch wide and $1\frac{3}{4}$ inches long. They are

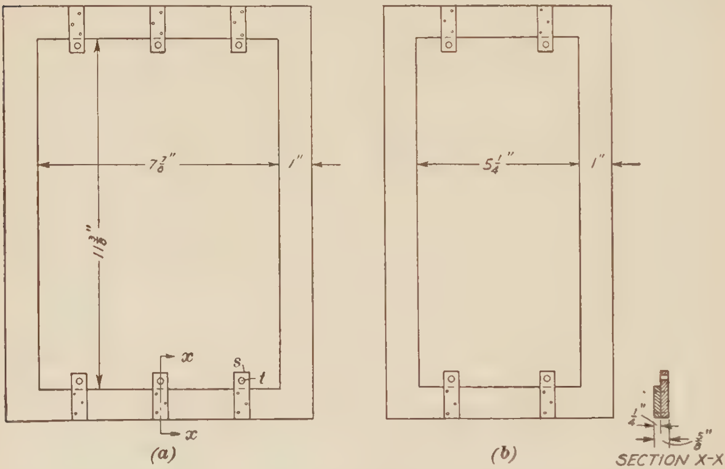


FIG. 46

riveted in place with three No. 12, or $\frac{3}{16}$-inch, steel rivets, after the guides have been hardened by heating them to a cherry red in a furnace and quenching them in cool water or oil. The holes *t* in the guides, which are to be duplicated on the pattern plate, are drilled with a No. 14 drill before hardening.

85. The pattern plate shown in Fig. 45 is next placed in the jig, Fig. 46 (*a*), and a No. 15 drill is run through the holes *t* in the jig and through the steel inserts *r*, Fig. 45, in the plate. The holes so formed are tapped with a No. 12-24 tap. The patterns are held on the plate by the fusing fast of the white metal to the tinned screws on the cope side of the pattern. The

only part of the patterns on the plate which requires finishing is the cope side, and generally this comes out of the mold very smooth and to size, so that rubbing with No. 0 sandpaper is sufficient to finish the cope side.

86. The second pattern plate to be mounted in the same fixture as the larger plate is shown in Fig. 47. It is $5\frac{1}{4}$ inches wide and $11\frac{3}{8}$ inches long, and on it are mounted six white-metal patterns of the cast-iron ratchet stop shown in Fig. 43 (*b*). A wooden master pattern is first made, two shrinks being used, one of $\frac{3}{64}$ inch for the white-metal working pattern and one of

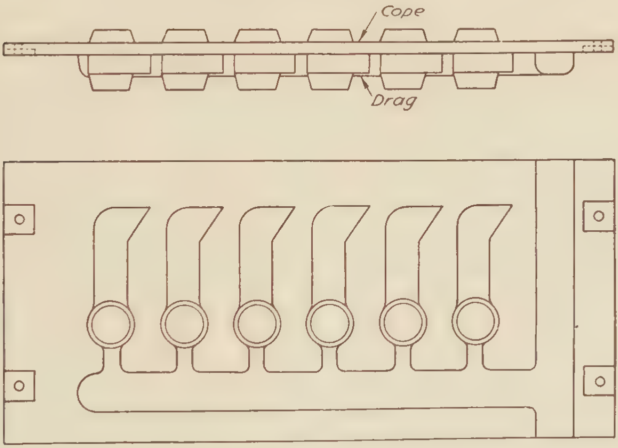


Fig. 47

$\frac{1}{8}$ inch for the iron casting. The only dimension that needs to be exact is the distance from the center of the boss to the end of the casting. Six white-metal castings are made and filed to size with a flat solder file. The finishing is done with No. 0 sandpaper. The patterns are provided with draft on all sides in the drag, as shown at *k*. A mold is made, with the patterns and runner laid out as shown in Fig. 47, the lug *v*, Fig. 43 (*b*), being molded in the drag half. Two steel inserts are placed in the slots at each end of the casting frame as it is located on the drag. The patterns are removed from the mold after being marked as explained before, and three No. 10-32 flat-head

machine screws that have been tinned are placed in the cope side to hold the patterns on the plate. Next, the white-metal casting is checked for thickness which should be $\frac{1}{4}$ inch, and then it is filed, scraped, and finished with No. 0 sandpaper. The plate is then placed in the small drilling jig shown in Fig. 46 (*b*), and the four holes drilled through the jig guides into the plate with a No. 15 drill. These holes, which are tapped with a

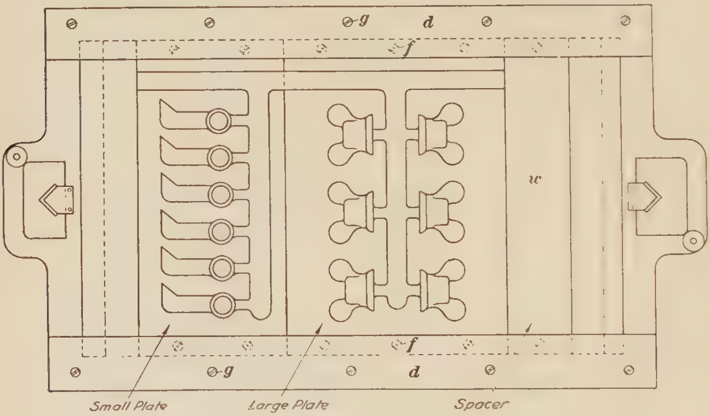


FIG. 48

No. 10-32 tap, are for the screws that fasten the plate to the fixture.

87. Finally, the two completed pattern plates shown in Figs. 45 and 47 are mounted in the fixture, Fig. 48. The small pattern plate is placed to the extreme left with the runners facing upwards. The large pattern plate is placed to the right of the smaller plate and a brass spacer *w* is used to fill the recess. This spacer is wide enough to provide a space in the end of the mold to place the sprue. The clamping pieces *d* along the sides of the fixture are next fastened to the fixture with No. 12-24 flat-head machine screws *g* and the same size screws *f* are used to fasten the pattern plates to the fixture, which is then ready for the molding machine.

METAL-PATTERN MAKING

(PART 3)

Serial 2233C Edition 1

METAL-PATTERN MOUNTING—(Continued)

MOUNTING PATTERNS ON MOLDING MACHINES

MOUNTING ON CAST PATTERN PLATES

1. General Remarks.—When many castings are to be made from a pattern that is of such shape that it cannot be mounted on a $\frac{1}{8}$-inch thick steel plate, a cast aluminum pattern plate is made. The method of making a large number of iron castings of the motor shield shown in Fig. 1 will now be described.

The shield is to fit on the end of an electric motor and forms the bearing for the armature shaft, and its dimensions must conform very closely to those given on the drawing. Because of its hollow back, the pattern will be difficult to mount on a $\frac{1}{8}$-inch thick steel plate, and a different method must be used for molding this casting. The hole *a* through the center of the casting is to be cored out with a dry-sand core, so the core prints *b* and *c* shown in the sectional view are placed on both ends of the boss *d* on the pattern.

2. Construction of Master Pattern of Motor Shield.—A wooden master pattern is first made with a double shrink of $\frac{5}{32}$ inch per foot for an aluminum working pattern and $\frac{1}{8}$ inch per foot for the iron castings. The bosses *e* on the outside edge of the pattern are made solid. Because of their size, only two patterns can be mounted on a plate that will fit in a 10″×18″ flask; therefore, only one extra master pattern will be required besides the original wooden pattern. This second master pat-

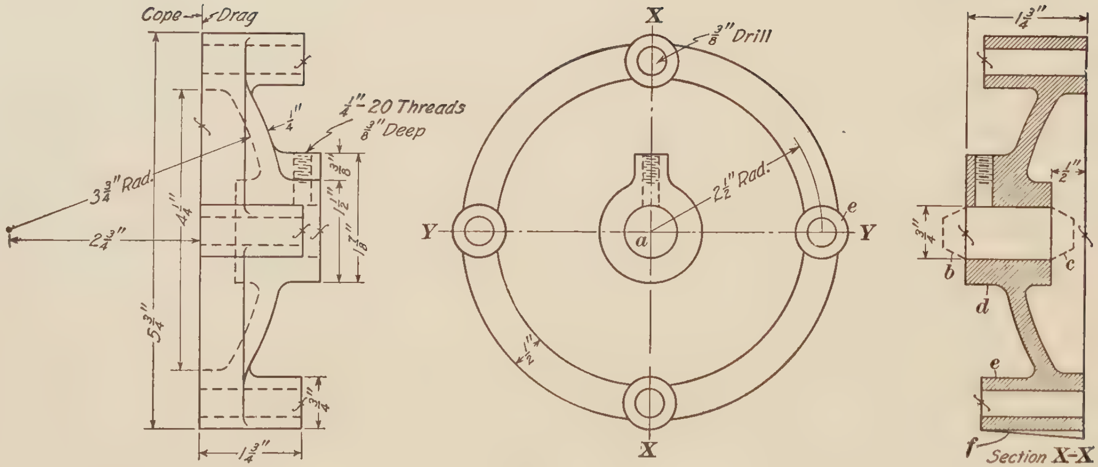

Cope
Drag
$3\frac{3}{4}''$ Rad.
$2\frac{3}{4}''$
$4\frac{1}{4}''$
$5\frac{3}{4}''$
$\frac{1}{4}''$
$\frac{1}{4}''$-20 Threads
$\frac{3}{8}''$ Deep
$\frac{3}{8}''$
$1\frac{1}{2}''$
$1\frac{7}{8}''$
$\frac{3}{4}''$
$1\frac{3}{4}''$
X
$\frac{3}{8}''$ Drill
$2\frac{1}{2}''$ Rad.
Y
a
e
Y
$\frac{1}{2}''$
X
$1\frac{3}{4}''$
$\frac{1}{2}''$
$\frac{3}{4}''$
b
c
d
e
f
Section X-X

FIG. 1

tern will be of white metal cast from the wooden pattern and filed and scraped to the same size as the wooden master pattern. In the process of molding, the wooden pattern is rapped so as to make the mold about $\frac{1}{32}$ inch larger, before the cope and pattern are removed. This is done to make the white-metal casting the same size as the wooden master pattern and to overcome the shrinkage of the white metal. The draft given to these patterns, shown at f on Section X-X, Fig. 1, is about $\frac{1}{32}$ inch, and is made in the same direction on all surfaces that are drafted.

3. The correct dimensions as indicated on the drawing apply about halfway between the top and bottom of the pattern; thus, the tops of the bosses c are $\frac{1}{64}$ inch smaller, and the bottom

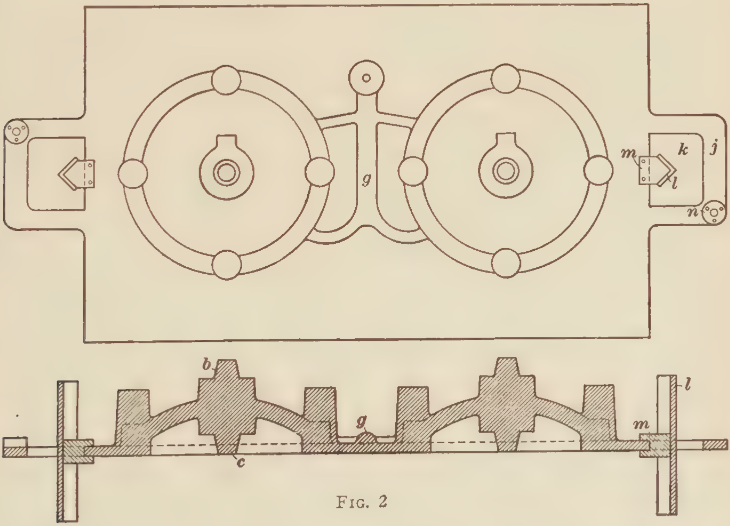


Fig. 2

$\frac{1}{64}$ inch larger than the drawing size. When the finish marks on the drawings indicate that the surface of the casting is to be finished, an allowance of $\frac{3}{32}$ inch is added to the patterns to permit of machining the castings. A hole for a drawhole is drilled, with a No. 12 drill, in the center of the core print on the cope side of the metal master pattern. The master patterns are then laid on a bottom board, exactly as they are to be located on the pattern plate, and a wooden runner pattern g, Fig. 2, is placed

between them. A sand mold is next made of the master patterns and the runner, after which the cope is removed and the patterns and runner in the drag are drawn from the sand.

4. Construction of Casting Frame for Motor Shield.—A steel casting frame is required to go around the molds made by the master patterns. This frame is made of cold-rolled steel $\frac{5}{16}$ inch thick, which is the thickness of the required aluminum plate. The bars that form the sides of the frame are $1\frac{1}{2}$ inches wide and 20 inches long, and the end bars are 4 inches wide and 15 inches long. A rectangular space *h* measuring 3 inches by 4 inches is sawed out of the end bars, and afterwards finished by filing. These spaces in the casting frame will form the handles of the aluminum pattern plates. The side and end bars are next welded together into a rectangular frame, by first fastening the bars in their correct relative position on a smooth board by means of nails with large heads driven along the edges of the bars. Care must be taken to make the inside dimensions of the built-up frame exactly 12 inches by 20 inches before welding the frame together. The welded joints are ground smooth and to a thickness of $\frac{5}{16}$ inch, after which the frame is straightened on a surface plate with a rawhide mallet. The frame should be absolutely straight, as otherwise the molten metal that is afterwards poured in the mold surrounded by the casting frame will run out of the mold between the sand and the frame.

5. A draft of $\frac{1}{32}$ inch is filed on the inside edges of the casting frame, Fig. 3, in order to facilitate the removal of the cast aluminum pattern plate from the frame. Two holes *i* are drilled in each end of the casting frame, with a No. 12 drill, and serve as drawholes. Into these holes sharpened wood dowel pins are driven, which act as handles for use in setting the casting frame around the mold made by the master patterns. The dimensions of the aluminum pattern plate cast inside the frame will be 12 inches by 20 inches, which is plenty of space to allow a $10'' \times 18''$ flask to be placed on the plate.

6. Molding Pattern Plate for Motor Shield.—In casting the aluminum pattern plate, the casting frame is placed cen-

trally on the drag mold made by the two master patterns, as shown in Fig. 2, thus holding the cope and drag halves of the mold $\frac{5}{16}$ inch apart. The sprues for the mold are made in the form of a wedge $\frac{1}{2}$ inch thick and 4 inches wide at the bottom near the casting, and 12 inches high. The advantages of the wedge-shaped sprue are that the flow of metal in the sprue is retarded so that the metal does not strike the mold with sufficient force to damage it, and the shape allows the sprue to be knocked off, or cut off, very easily. Another advantage is that the metal in the mold near the junction with the sprue is not

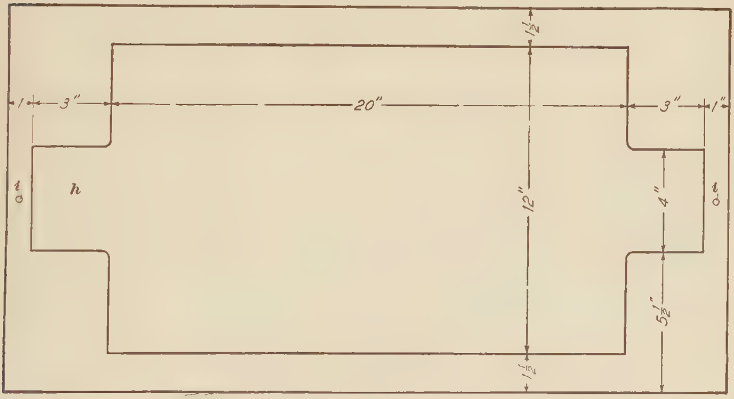


Fig. 3

so liable to cause shrink spots as when round sprues are used. Four sprues are used to pour the aluminum plate, one sprue being placed at each corner. The extra height of the sprues enables the metal to have sufficient head to be fed to the thin parts of the mold, and prevents the casting from unduly shrinking at the corners. It necessitates, however, the use of a deep cope or a pouring box on top of the cope. A riser 2 inches in diameter is placed near the center of the mold.

7. The alloy used in pouring the mold consists of a mixture of aluminum and zinc in the proportion of 92 pounds of aluminum to 8 pounds of zinc. After the cope is closed over the casting frame and the drag, the mold is poured with two ladles from two sprues in opposite corners. The casting is

removed from the mold as soon as possible. If the casting is allowed to remain too long in the mold, a thick gray scale will collect on its surface and be difficult to remove. The casting should not be cooled with water or extremely cold air, as this might crack and spoil it. When the casting is sufficiently cool, the casting frame is removed and the sprues are sawed off or removed by drilling holes through them close to the plate with a $\frac{1}{4}$-inch drill and knocking the sprues off with a light hammer blow.

8. The thickness of the cast aluminum pattern plate shown in Fig. 2 is next checked for accuracy and uniformity. In checking the thickness of the pattern, $\frac{5}{16}$ inch, which is the thickness of the plate under the pattern, must be added to the pattern dimensions on the drawing, all measurements being made with a $\frac{1}{8}$-inch shrink rule. The plate and patterns are filed and scraped to size, after which they are finished by sandpapering, first with No. 1 and afterwards with No. 0 sandpaper. The core prints *b* and *c*, Fig. 2, are stamped *Core*, to indicate to the molder the various places where cores are used. The handles *j* are next formed by drilling a series of $\frac{1}{4}$-inch holes inside the outline of the rectangles *k* laid off on the handles and cutting away the metal between the holes. The sides of the holes *k* are then smoothed off to the exact lines with a flat bastard file.

9. The flask pins *l*, Fig. 2, are riveted to the blocks *m* at the ends of the plate by use of two No. 12 rivets in each pin. The blocks *m* are riveted to the plate by two rivets of the same size. The plate is next placed on a surface plate on two parallels, each 3 inches high, 1 inch wide, and 20 inches long, and the pins *l* are checked with a square to ascertain whether they are square with the plate. If they are found to be out of line, a large wrench may be used to bend them in place. The length of the pins is 5 inches. Each handle is provided with a vibrator boss *n* made of $\frac{3}{16}$-inch sheet brass turned on a speed lathe to a diameter of 1 inch, and riveted to the handles with three No. 12 steel rivets. A hole $\frac{5}{16}$ inch in diameter is drilled in the center

of each boss and through the plate for the bolt which fastens the vibrator to the plate. The plate is then ready for use.

10. Construction of Core Box for Motor Shield.—A core box is required for making the core used to form the hole for the bearing in the center of each casting. The box is made of cast iron and is shown in Fig. 4. The hole to be cored in the

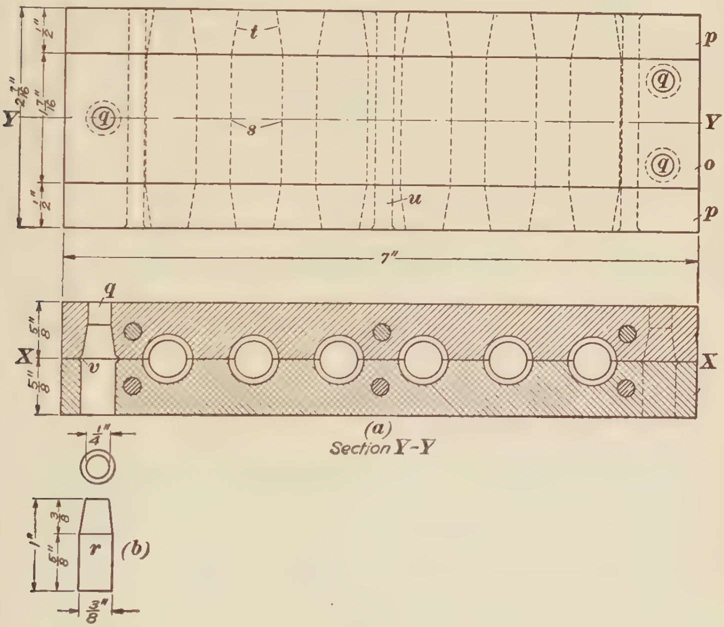


FIG. 4

center of each pattern has a diameter of $\frac{3}{4}$ inch, and as $\frac{3}{32}$ inch is allowed on the sides of the hole for finishing, the cores will have a diameter of $\frac{3}{4}$ inch less $2\times\frac{3}{32}$ inch, or $\frac{9}{16}$ inch. The length of the body of the core is obtained from the length of the boss at the center of each pattern, which is $1\frac{1}{4}$ inches. With allowance for finish on both ends of the boss, the length of each core will be $1\frac{1}{4}''+2\times\frac{3}{32}''$, or $1\frac{7}{16}$ inches. To this length must be added the lengths of the two core prints at the ends of the core, and as each print is $\frac{1}{2}$ inch long, the total length of each core will be $1\frac{7}{16}+1=2\frac{7}{16}$ inches.

11. The total length and diameter of each core having been determined, the cast-iron members that make up the core box may next be laid out. Two iron bars *o*, Fig. 4 (*a*), cast from a wooden pattern are finished in a shaper to a thickness of $\frac{5}{8}$ inch, a width of $1\frac{7}{16}$ inches, and a length of 7 inches. Four other cast-iron bars *p* are finished to a thickness of $\frac{1}{2}$ inch, a width of $\frac{5}{8}$ inch, and a length of 7 inches. The two bars *o* are clamped with the $1\frac{7}{16}$-inch wide faces together and three holes *q* of $\frac{1}{4}$ inch diameter drilled through both bars. The clamps are then removed and a $\frac{3}{8}$-inch drill is run through the holes in the bottom bar and part way into the top bar, after which a taper reamer is used to taper the hole in the top bar, as shown in the sectional view. A pin *r*, shown in view (*b*), having a tapered point $\frac{3}{8}$ inch long, and made of cold-rolled steel rod $\frac{3}{8}$ inch in diameter, is driven into each hole in the bottom bar until the tapered point fits snugly in the taper hole in the upper bar. Two pins are used on one end of the core box and only one pin on the other end to prevent the core box from being closed with the halves in the wrong position. This point should always be considered in making symmetrical patterns and core boxes.

12. In turning the pins *r*, Fig. 4 (*b*), on a lathe, care must be taken to have the stock run true, otherwise the pin will shift the upper part of the core box out of line when the box is closed. The bars *o*, view (*a*), are then clamped together again and the centers of the cores are prick-punched on the line of parting *XX*, the distance between two centers being $\frac{15}{16}$ inch. The holes *s* are drilled at the punch marks with a $\frac{1}{4}$-inch drill, after which the holes are bored with a $\frac{9}{16}$-inch counterbore having a $\frac{1}{4}$-inch pilot. The object of boring the core holes is to make the holes truly cylindrical. The holes so formed serve to make the body of the core, while the core prints are formed by the taper holes *t* in the end bars *p*. These bars are clamped in pairs with the $\frac{1}{2}$-inch faces together. The centers of the core holes are prick-punched on the end bars *p* $\frac{15}{16}$ inch apart. The holes are drilled with a $\frac{11}{32}$-inch drill, after which a taper reamer is run through the holes until the diameter is $\frac{9}{16}$ inch at the top and $\frac{3}{8}$ inch at the bottom.

13. Each half of the core box, Fig. 4 (*a*), is then completed by riveting one of the bars *p* to each side of one of the large bars *o* by three No. 12 steel rivets *u*. All burrs and sharp edges are removed with a mill file, and the corners at the parting line are beveled off at 45 degrees, as at *v*, on an emery disk or with a file. This is to prevent the two halves of the box from being held apart by a burr or upset edge, which would result in an increased thickness of the core and reduce the amount of metal allowed for finishing the hole.

The core box is stamped on each half with the same identification mark as the pattern plate with which the cores are used, the stamp usually consisting of the number of the drawing of the casting.

SPECIAL METHODS OF MOUNTING METAL PATTERNS

14. Methods of Molding Pulley Wheel.—Pulley-wheel castings, one form of which is shown in Fig. 5, may be made with three different kinds of pattern equipment. In the first

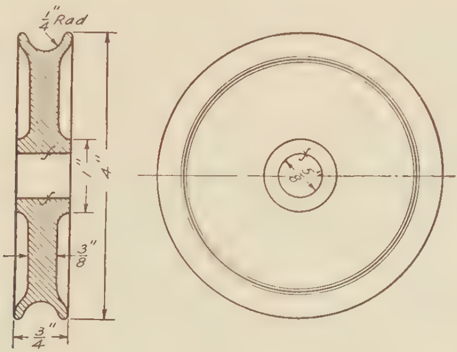


Fig. 5

method, a solid pattern is made of the wheel as shown in Fig. 6, and a core print *a* is placed around it to core out the groove in the rim. A dry-sand core is used in the impression in the mold made by the print, and consequently this method requires the construction and use of a core box.

In the second method, a split pattern or a plate of split patterns is used, as shown in Fig. 7 (*a*), without the use of dry-

sand cores. In molding this plate of patterns the recess *b* in the plate must be rammed full of sand, as shown in view (*b*),

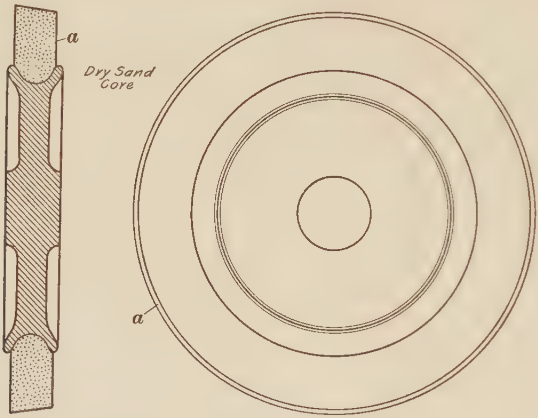


Fig. 6

before the upper parts *c* of the patterns are in place to make the drag.

15. In the third method of molding the pulley wheel shown in Fig. 5, which will be treated in detail, a half pattern is used on a rotating shaft and no dry-sand cores are required. The

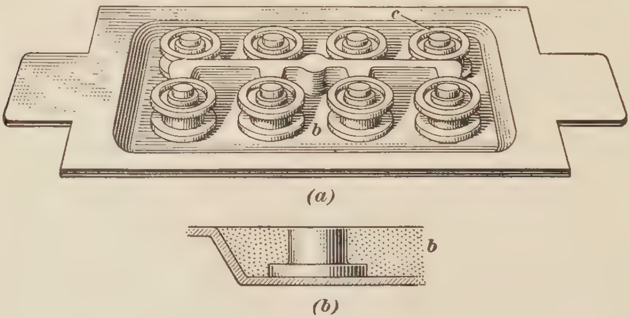


Fig. 7

manner of mounting the pattern is one of a number of special mountings which, although themselves expensive, produce a large number of castings economically. The dimensions of the casting must be very close to those on the drawing. In this

method a master pattern is first made of wood with a double shrink of $\frac{3}{16}$ inch per foot for the brass working patterns cast from the master pattern, and $\frac{1}{4}$ inch per foot for the iron castings. The master pattern is made as a half pattern, as shown in Fig. 8. The boss *d* is made solid and the outside rim *e* containing the groove is made straight in order to make the molding of the castings for the working patterns less complicated. For finishing the brass pattern castings $\frac{1}{8}$ inch of metal is allowed all over the master pattern, and the sides have a draft

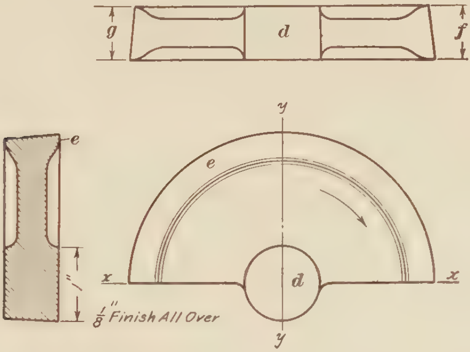


FIG. 8

of $\frac{1}{32}$ inch per inch. The line of parting of the pattern is the line *xx*.

16. Working Patterns of Pulley Wheel.—The master pattern, Fig. 8, is used to make fourteen brass working patterns, which are as many as can be molded in a $10'' \times 18''$ flask. These patterns must be absolutely free from defects such as rough spots, blowholes, etc., for the reason that the patterns are to be mounted on a shaft and the shaft rotated in drawing the patterns out of the sand. The surfaces of the patterns must be very smooth, otherwise the sides of the molds will crumble. The castings of the working patterns are first prick-punched in the center of the bosses and a $\frac{39}{64}$-inch hole is drilled through the centers. The hole is reamed out with a $\frac{5}{8}$-inch straight reamer which is run into the hole for about half its length so as to make the hole a tight sliding fit for a $\frac{5}{8}$-inch shaft.

17. Each casting is then mounted on a mandrel in a lathe and machined with a taper in such a way that the thickness at *f*, Fig. 8, is slightly greater than at *g*, so that the patterns can be drawn from the sand when they are rotated in the direction of

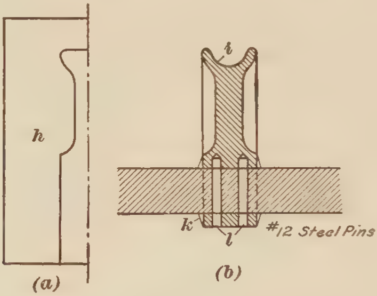


FIG. 9

the arrow. As this difference in thickness constitutes the draft on the pattern, a very accurate check for the thickness is made by means of a $\frac{1}{32}$-inch thick sheet-metal templet *h*, Fig. 9 (*a*), which is used to check the sides and boss of each pattern with the center line.

A groove *i*, view (*b*), is also cut in the pattern rim, after which the patterns are smoothed with No. 0 sandpaper and then polished with very fine emery cloth and oil, care being taken to have all scratches caused by the abrasive run in the direction of rotation of the patterns. The patterns are then mounted on

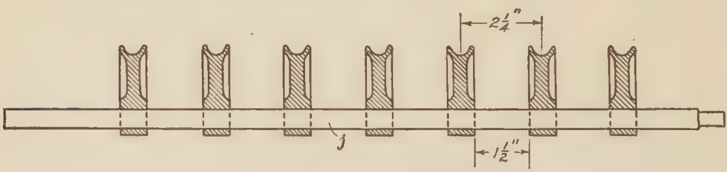


FIG. 10

two cold-rolled steel shafts of $\frac{5}{8}$-inch diameter and 24 inches long. Seven patterns are mounted on each shaft as shown in Fig. 10. The shafts *j* are turned to size in a lathe and the ends are milled $\frac{1}{2}$ inch square. The draft on the patterns is such that all the thin sides of the patterns are on the same side of the

shaft, which causes the draft to be in the same direction when the shaft and patterns are rotated.

18. The patterns are next soldered to the shaft *j*, Fig. 10, the distance between the bosses being made $1\frac{1}{2}$ inches. The solder is filed so as to produce a $\frac{1}{64}$-inch draft on the sides of the bosses as shown at *k*, Fig. 9 (*b*). In each pattern, two holes *l* are drilled through the shaft with a No. 13 drill, and two

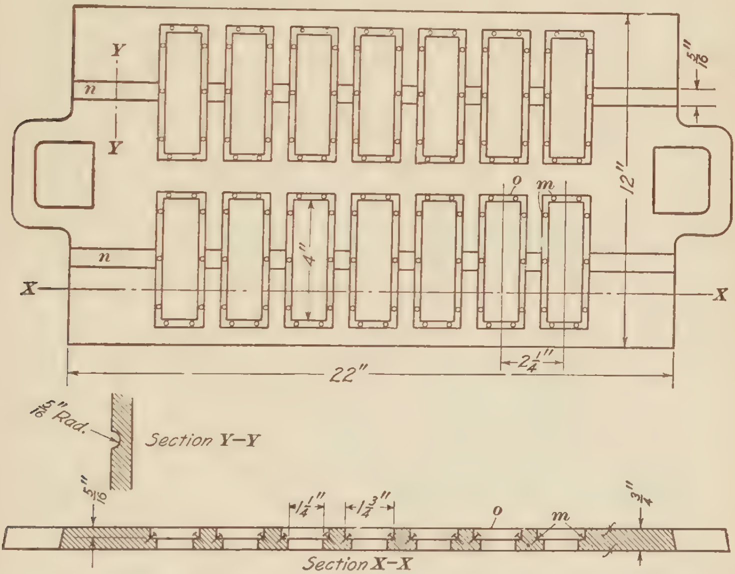


FIG. 11

No. 12 steel pins $\frac{7}{8}$ inch long are driven into the holes to hold the patterns on the shaft.

The shaft and patterns are then tested in a lathe to see whether they are square with each other; this is done by mounting the shaft between the centers of the lathe and checking the sides of the patterns with a square resting on a face plate laid across the ways of the lathe. This test is important; because, if the patterns are not square with the shaft, they will crush the sand in the mold when they are being rotated.

19. Stripper Plate.—A cast-iron plate, shown in Fig. 11 and known as a stripper plate, is made from a wooden master

pattern on which allowance is made for $\frac{1}{8}$ inch of metal on each surface marked with a finish mark on the drawing. Rectangular holes *o* are cast in the plate, the center lines of the holes being spaced the same distance apart as the distance between the center lines of the patterns as they are mounted on the shaft, or $2\frac{1}{4}$ inches apart. The plate is finished on both sides to a thickness of $\frac{3}{4}$ inch, and the shaft grooves *n* are milled out with a convex milling cutter having a radius of $\frac{5}{16}$ inch. In the recess of each rectangular hole ten small holes are drilled at an angle

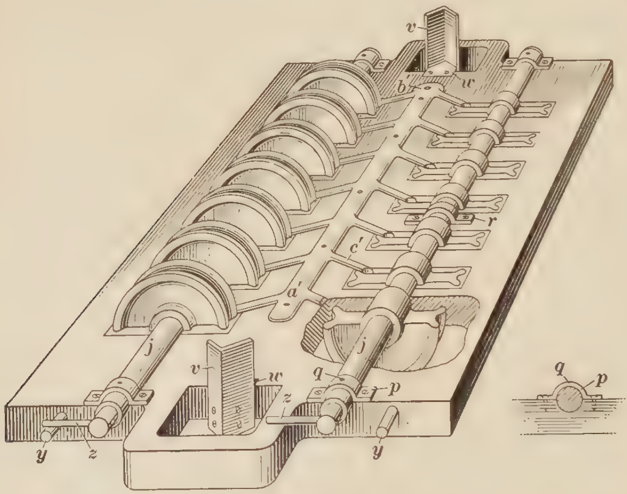


Fig. 12

by use of a No. 31 drill. In each of these holes is driven a sixpenny nail *m* that has been cut off to a length of $\frac{3}{4}$ inch. These nails are driven so that the heads are below the top of the plate and they serve as anchors for the white metal which is afterwards poured in the rectangular holes.

20. The shafts with the patterns mounted on them are laid in the grooves *n*, Fig. 11, in the stripper plate and held down at the ends in bearings, as shown in Fig. 12. To make the bearings, four bronze bearing caps *p* are cast from a wooden pattern and ground flat on the side that fits against the plate; and the part that fits over the shaft is machined with a convex milling

cutter. An oil hole *q* is drilled through the top with a No. 30 drill and tapped with a No. 8-32 tap, so that a No. 8-32 round-head machine screw can be screwed into it to keep out dirt and grit. The caps are fastened to the plate close to the ends of the shafts with two No. 14-24 flat-head machine screws and hold the ends of the shaft, while allowing them to rotate freely. An additional bearing cap *r* is placed near the middle of each shaft. The caps *r* have a $\frac{1}{4}$-inch draft on each side to allow the sand in the mold to draw freely from them.

21. The shafts *j*, Fig. 12, carrying the patterns are revolved so that the patterns are above the surface of the plate, as shown in Fig. 13 (*a*). Then the bottom of the rectangular hole under

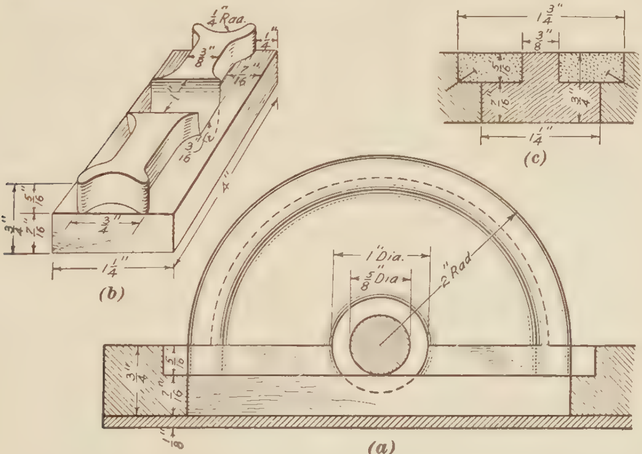


Fig. 13

one of the patterns is filled up with a block of wood. The upper part of this block is made to conform to the shape of the pattern, as shown in view (*b*), and is cut away enough around the hub to allow the block to fit up tight against the shaft and the hub. Before the block is put in place, it is charred with a blow torch until no white wood is visible. As molten white metal is to be poured into the hole around the block, a $\frac{1}{8}$-inch thick steel plate, view (*a*), is clamped to the bottom of the stripper plate to make sure that no molten metal will escape at the bottom of the hole. Next the stripper plate and the pattern are heated with a

blow torch to drive off any moisture that might cause the molten metal to kick, or blow, away from them. The charring of the wooden block likewise prevents any tendency of the metal to kick away from it. Next the hole is filled with white metal until it is about $\frac{1}{8}$ inch above the face of the plate. The block of wood is then removed and placed in another hole, and the process is repeated until all the holes are filled with white metal.

22. The bearing caps over the ends of the shafts *j*, Fig. **12**, are taken off and the metal that has covered the shafts is removed with a chisel after which the shafts and patterns are lifted out of the plate. The plate is then clamped on the table of a milling machine and all excess metal is milled off flush with the face of the plate, as shown in the cross-section, Fig. 13, (*c*).

The shafts and patterns are next replaced in the plate in the same position as when the white metal was poured around the patterns, and then are painted with prussian blue. The shafts are rotated as far as possible and then removed. If any blue marks show on the white metal, the surface affected is filed down with a flat solder file. This process is repeated until the patterns clear the white-metal surfaces on the plate by about .005 inch.

23. As a snap flask is to be used on the plate to make the mold, flask pins *v*, Fig. 12, made of angle iron are riveted to the blocks *w*, which in turn are riveted to the plate with No. 12 steel rivets. Stops *y* are provided to prevent the shafts and patterns from rotating too far. These stops consist of $\frac{3}{8}$-inch bolts screwed into the ends of the plate, the heads being afterwards sawed off. A $\frac{1}{4}$-inch cold-rolled steel rod *z* is driven into a hole drilled in the end of each shaft in such a way that the rod strikes the stop *y* when the patterns have rotated as far as they should.

A white-metal runner *a'* is cast from a wooden pattern and is held on the plate by five No. 10-32 flat-head machine screws, the heads of which are soldered over and then filed flush with the top of the runner. A $\frac{5}{16}$-inch hole is drilled through the runner in the center of the boss *b'* for the pin inserted in the end of the sprue pattern, so that in making the cope half of the mold

the sprue can be placed in the proper position over the boss. The gates *c'* are made $\frac{1}{8}$ inch thick, due to the fact that the runner is made in both cope and drag, and the total thickness must not exceed $\frac{1}{4}$ inch.

24. The shaft *j*, Fig. 12, half of which is above the face of the stripper plate, is used as a core print for the dry-sand core which makes the hole through the center of the pulley wheel. As the diameter of the hole is to be $\frac{3}{4}$ inch, a core having a body diameter of $\frac{5}{8}$ inch will leave $\frac{1}{16}$ inch of metal to be removed on each side of the hole. In making the cast-iron core box for the dry-sand core, two bars $\frac{5}{8}$ inch thick, $1\frac{3}{4}$ inches wide, and $8\frac{1}{2}$ inches long are cast from wooden patterns and machined to size on a shaper. The $1\frac{3}{4}$-inch faces are clamped together and three $\frac{3}{8}$-inch tapered pins are driven into holes that have previously been drilled and reamed. The blanks are again clamped together with the pins in place, and the centers of the holes for the cores are prick-punched $\frac{7}{8}$ inch apart on the parting line, thus allowing $\frac{1}{4}$ inch of metal between the core holes. A $\frac{1}{4}$-inch hole is drilled through the two bars at each punch mark, care being taken not to have the drill run off center. Next, a $\frac{5}{8}$-inch drill is run through the $\frac{1}{4}$-inch holes to form the holes in which the cores are made. If a sharp drill is used with a slow feed in drilling the holes, no additional finishing operations are required except for beveling off the sharp edges of the holes. The core box is stamped the same as the patterns.

25. Process of Molding Pulley Wheels.—In the molding process, the shafts and patterns are rotated until the patterns are below the plate, after which the mold can be lifted off the plate. The patterns when turned down do not strike the bench or the molding-machine parts, as the plate is supported on a frame made of pine wood 1 inch thick, 3 inches high, and as long as the plate. The finished plate is stamped *One Plate Cope and Drag,* to indicate that both the cope and the drag are made on the same plate. The face of the plate is painted with a solution of sal ammoniac and water, which causes it to rust very lightly. The plate is then heated and rubbed in with wax, which with the rust forms a coating that prevents further rusting when the

plate comes in contact with the damp sand in the foundry. The halves of the snap flask used on the plate must be cut out on each end to enable them to fit over the ends of the shafts that extend outside of the flask.

26. The mold is made by ramming up the drag without using the sprue pattern and turning the shafts on which the

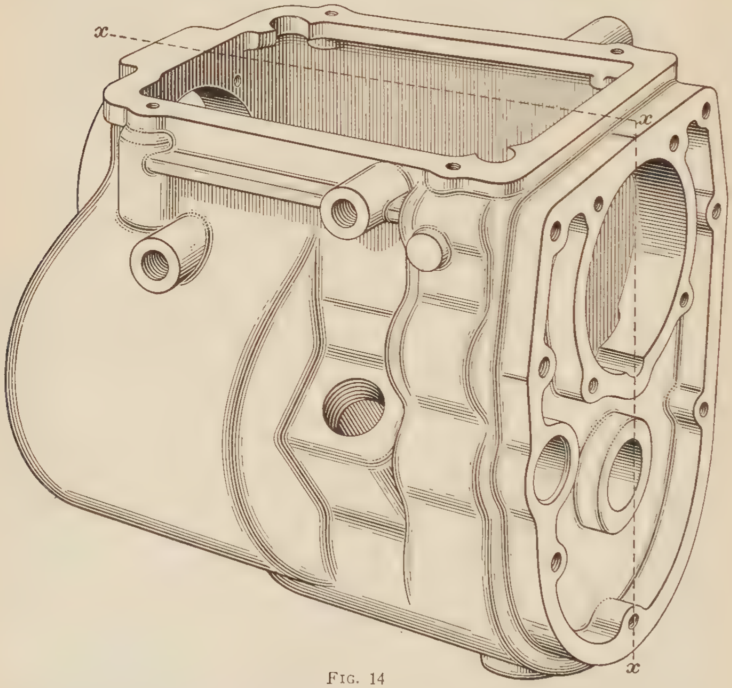


FIG. 14

patterns are mounted with a wrench placed on the square ends, until the rods z, Fig. 12, rest against the stops y, thereby drawing the patterns from the mold. The patterns are then taken out of the sand and the drag is lifted off. The cope is rammed up in the same way as the drag, except that the sprue pattern is set over the sprue boss in the runner. The patterns are turned the same as in the drag after the sprue pattern has been removed. The cores are next set in the depressions made by the shafts in the drag. As it is not practical to use the whole length of the

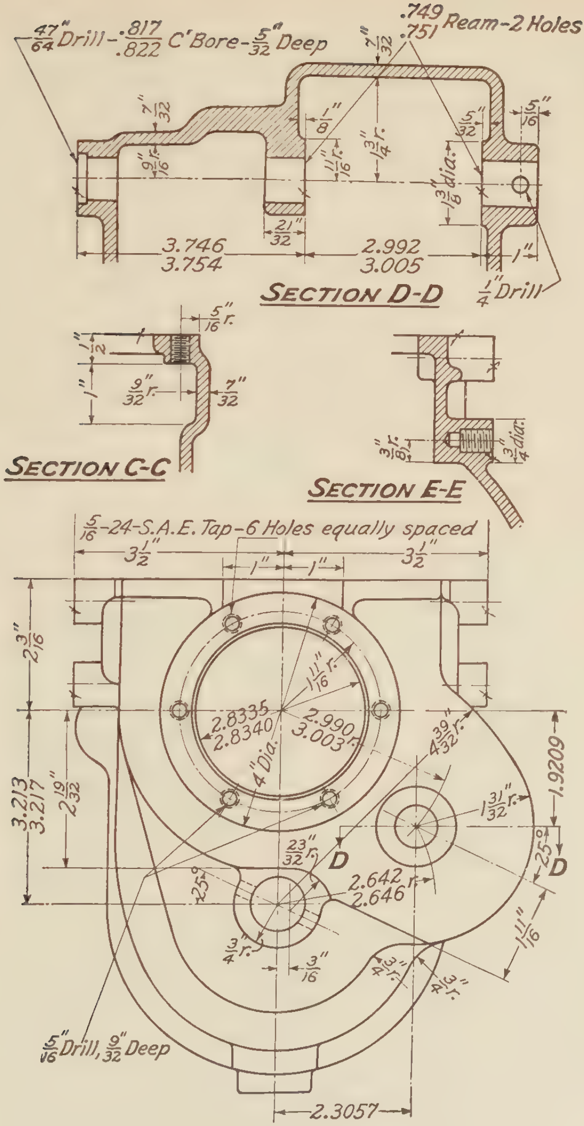

47/64" Drill - .817/.822 C'Bore - 5/32" Deep
.749/.751 Ream-2 Holes
SECTION D-D
1/4" Drill
3.746/3.754
2.992/3.005
SECTION C-C
SECTION E-E
5/16-24-S.A.E. Tap-6 Holes equally spaced
3 1/2"
2.8335/2.8340
2.990/3.003 r.
4" Dia.
1.9209
2.642/2.646 r.
3.213/3.217
5/16" Drill, 9/32" Deep
2.3057

FIG. 15 (*a*)

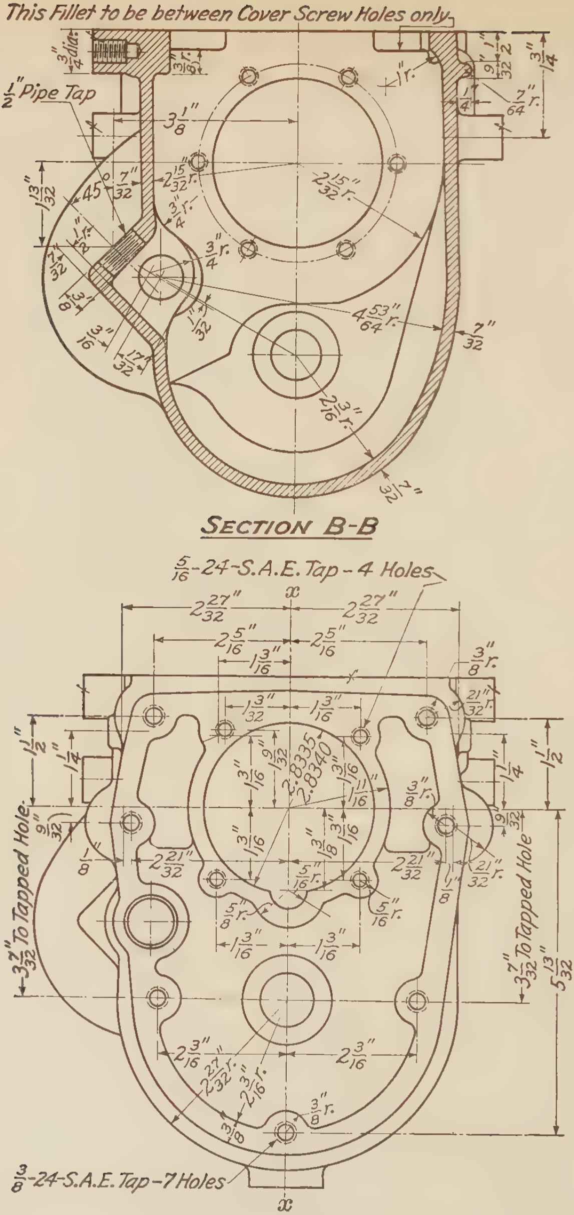
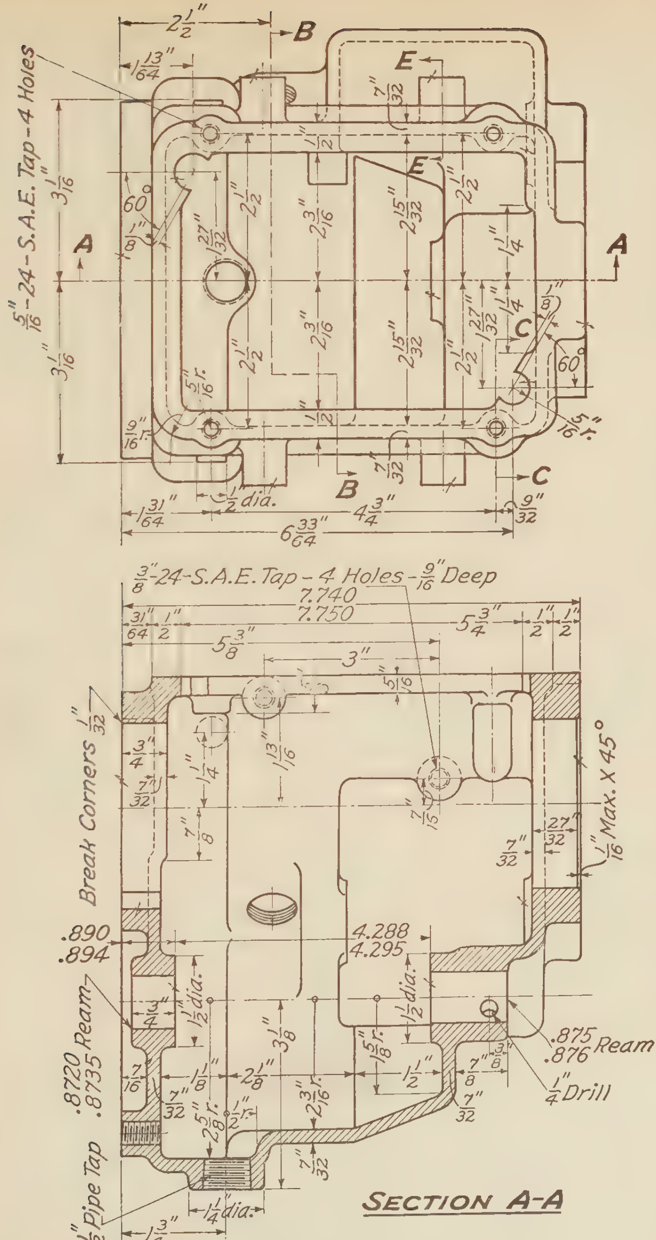

This Fillet to be between Cover Screw Holes only
$\frac{3}{4}$" dia.
$\frac{1}{2}$" Pipe Tap
SECTION B-B
$\frac{5}{16}$-24-S.A.E. Tap - 4 Holes
$\frac{3}{8}$-24-S.A.E. Tap - 7 Holes
$3\frac{7}{32}$" To Tapped Hole
x

FIG. 15 (b)



5/16"-24-S.A.E. Tap-4 Holes
3/8"-24-S.A.E. Tap-4 Holes-9/16" Deep
Break Corners 1/32"
1/16" Max. X 45°
.875 .876 Ream
1/4" Drill
.8720 .8735 Ream
.890 .894
4.288 4.295
7.740 7.750
1/2" Pipe Tap
SECTION A-A

Fig. 15 (c)

shaft *j* as one core print, each core is set in the proper depression about central with the pattern.

27. Gear-Case Patterns.—For patterns larger than those previously described, cast aluminum plates are used. The iron casting shown in Fig. 14, which is a transmission gear case for

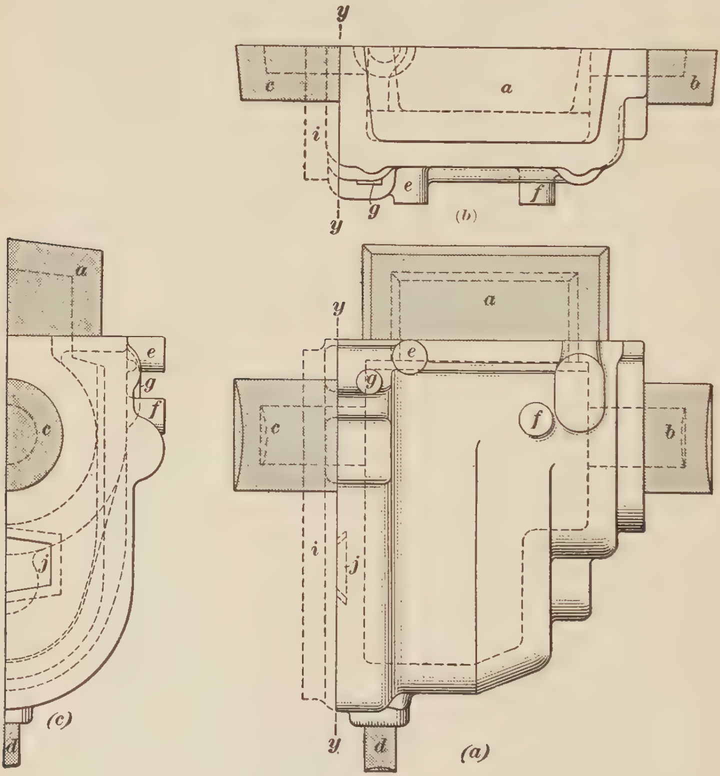


FIG. 16

an automobile, is an example of this kind. The drawings for this casting are shown in Fig. 15 (*a*), (*b*), and (*c*).

The box is of cylindrical form with a large rectangular opening at the top side. The opening is arranged to receive a flat coverplate. The walls of the case are mainly $\frac{7}{32}$ inch thick, and the case has numerous bossed circular openings to receive

the gear shafts and the gear-shifting mechanism for changing the speed of the car. The bosses on the left-end openings form overhangs, and the undercuts on the right end of the case complicate the patterns. There are also some interior bosses that complicate the core boxes.

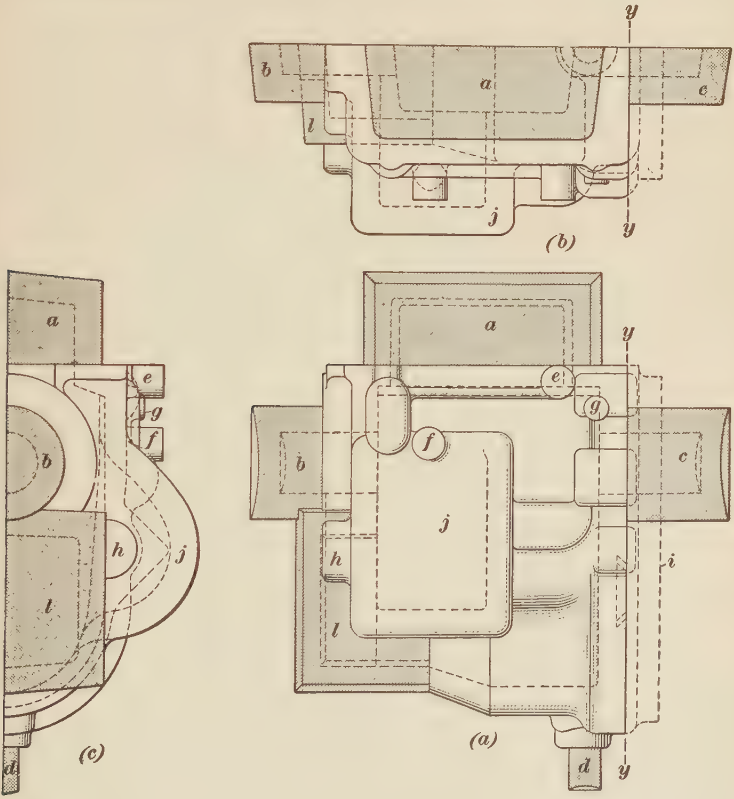


FIG. 17

28. Wooden Master Patterns of Gear Case.—The wooden master patterns of the gear case, Figs. 14 and 15, are shown in Figs. 16, 17, 18, and 19. The body of the pattern consists of two main parts, Figs. 16 and 17, that are parted on a central plane indicated by the dotted line *x-x-x* in Fig. 14. The lighter part of the body pattern, Fig. 16, which is used to form the cope mold, indicates the general requirements of the master

pattern. The pattern is made hollow for lightness and about $\frac{5}{8}$ inch thick, and with an inside draft of $\frac{1}{16}$ inch. Core prints *a*, *b*, *c*, and *d* are located where the openings must be cast, and bosses such as *e*, *f*, *g*, *h*, etc., are used where the openings are to be drilled. A double shrink of $\frac{5}{32}$ inch per foot for the aluminum working patterns cast from the master patterns, and $\frac{1}{8}$ inch per foot for the iron castings must be allowed. Also all the outside dimensions of the master patterns must be increased by

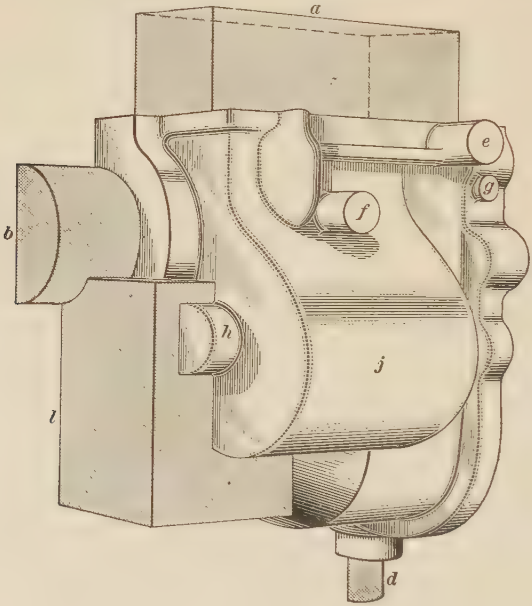


FIG. 18

$\frac{1}{32}$ inch so that the surfaces of the aluminum working patterns may be finished. The end part *i*, views (*a*) and (*b*), which makes the mold for the undercuts shown on the right-hand end of the box, Fig. 14, is made separate from the body of the pattern. The parting line is *y–y*, views (*a*) and (*b*) in Fig. 16. The part *i* is attached to the body by means of a tapered dovetail *j*; so that after the body of the pattern with its core print *c* has been lifted from the mold, the part *i* of the pattern can then be drawn back into the main mold cavity and be lifted out.

View (c) shows the end view of the body pattern with the draw-back part i removed. Half of the draw-back i goes with the cope part of the body pattern and half with the drag part.

29. The heavier part of the body pattern, which is used to make the drag mold, is shown in Fig. 17. A general, single view of this pattern exclusive of the part i is shown in Fig. 18. It is heavier than the other part because of the enlargement j on the side. In addition to the half prints a, b, c, and d, which match those on the half pattern, Fig. 16, the half pattern in

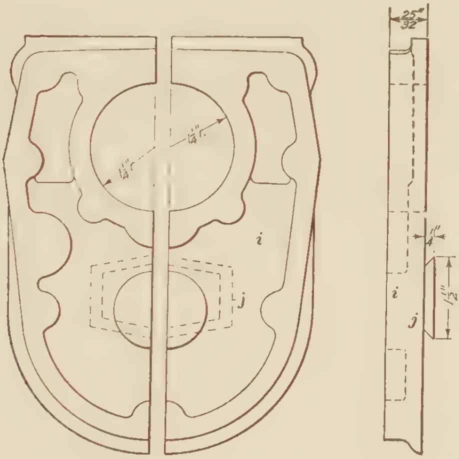


FIG. 19

Figs. 17 and 18 has an extra print l to cover the overhanging boss h. The cavity formed in the mold by the print l must be filled by a dry-sand core made from a box described later. About $\frac{1}{8}$ inch draft is given to the ends and sides of the rectangular core prints, and the same on the ends of the cylindrical prints, as shown.

30. The draw-back or end part i of the master pattern, Figs. 16 and 17, which is attached to the body patterns by taper dovetails j, is shown in detail in Fig. 19. It is made in two symmetrical pieces, one right and one left, which fit the respective parts of the body patterns and around the $2\frac{1}{2}$-inch core

print *c* that extends through them. All the allowances for shrinkage, and for finishing made on the body patterns must be applied to the draw-back *i*.

31. Aluminum Working Patterns for Gear Case.—Two aluminum castings are made from each half of the body of the

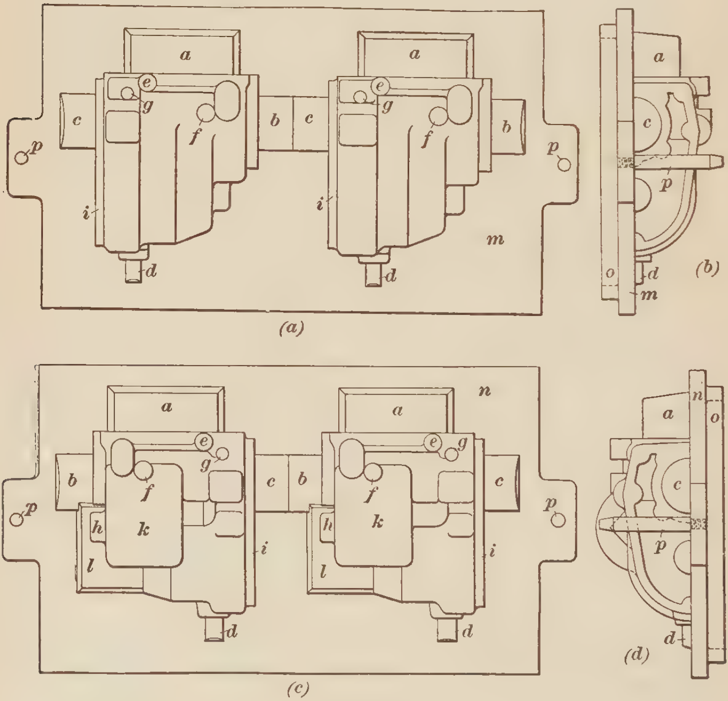


FIG. 20

master pattern, and two from each half of the draw-back master pattern, which are shown in Figs. 16, 17, 18, and 19. These castings are ground, scraped, and filed to the working-pattern size. This finishing is done while the mated castings are clamped together so as to form a whole pattern. By this method the surfaces of the patterns will coincide perfectly at the parting lines. The inside surfaces of the working patterns need not be finished. The draw-back dovetails *j* must be free fitting so

that they will separate easily and not tear the mold when the body patterns are being removed from the molds.

32. Mounting Working Patterns of Gear Case.—Two thick aluminum plates *m* and *n*, Fig. 20, are cast from a wooden pattern. A stiffening flange *o* extends around the under side of the plates, and both sides of the plates are surfaced on a shaper or a miller. A center line is drawn on each plate and the holes for the steel flask pins *p* are located. Lines parallel to the center lines also are drawn for the purpose of locating the centers of the core prints *b* and *c*. Both plates must be laid out identical in order that the cope mold from plate *m* will exactly register with the drag mold from the plate *n*. The two similar half patterns are clamped on the plate *m* and the two patterns of the other corresponding halves are clamped to the plate *n*. The plates are then turned over and holes are drilled through them into the patterns, the holes in the patterns being tapped for $\frac{3}{8}$-inch thread, hexagonal-head, machine bolts. Six equally spaced bolts are used in each half pattern. Two $\frac{3}{8}$-inch diameter steel dowel pins are also put through the plate and into each half pattern to prevent the patterns from moving out of line when in service and to allow the patterns to be replaced easily and exactly in case they are removed for repairs.

33. Core Boxes for Gear Case.—A core box must be made for the large core that forms the inside of the gear case, together with its prints *a*, *b*, *c*, and *d*, Figs. 16 and 17, and one must be made for the outside core that fills the mold cavity formed by the core print *l* in Figs. 17, 18, and 20. Both of these core boxes are made of aluminum cast from wooden master patterns. The master patterns must have a double shrinkage allowance of $\frac{5}{32}$ inch per foot for the aluminum core-box castings and $\frac{1}{8}$ inch per foot for the cast-iron castings. Also from $\frac{1}{64}$ to $\frac{1}{32}$ inch must be allowed on the inside faces for finishing.

34. Core Box for Inside Core.—The box, Fig. 21 (*a*), for the inside core is made in halves parted, or split, on the same line as the pattern, or the line *z-z*. The walls of the box are made $\frac{5}{8}$ inch thick. At the large rectangular opening where the

core extends to the outside of the box, $\frac{1}{8}$ inch of metal is added to allow for a machine finish. The inside of each part of the box is similar to the shape of the inside of the corresponding part of the transmission-case casting. The outside of the core box must have four lugs *c*, views (*a*) and (*c*), on each half for

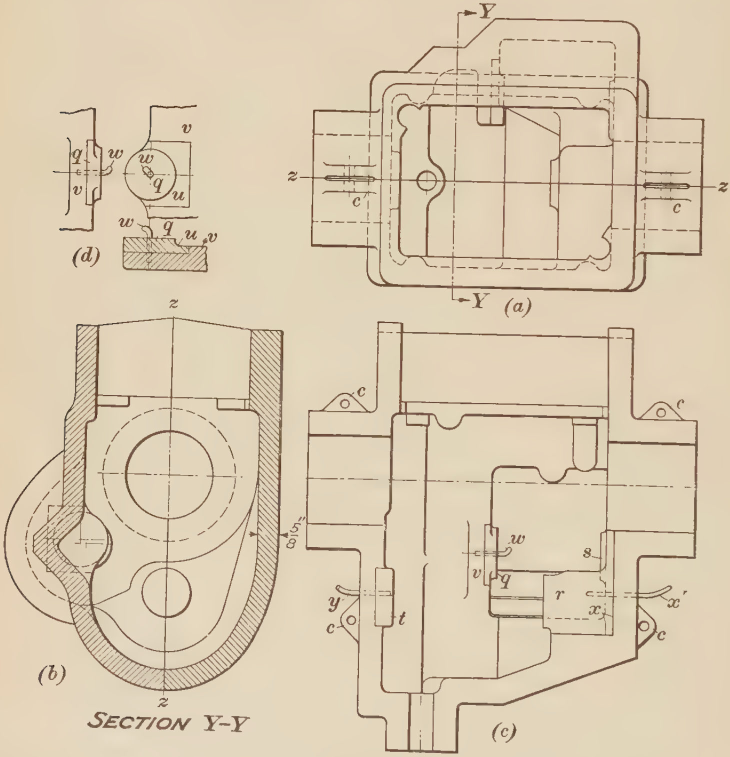


FIG. 21

pins that are used to line up and hold the halves together while the cores are being rammed up.

Provision must be made for molding the four inside bosses *q*, *r*, *s*, and *t* of the case in the core. As these bosses project into the core, it is necessary to make them loose, as shown in detail in view (*d*) for *q*, so that they can be molded in the core. The pieces are then left in the core when the halves of the box

are taken from the core, and the pieces can then be picked out of the core and replaced in the box. The pattern of the boss *q* is molded with a wing *u*, which is set into the wall *v* of the box; and the entire draw-back is held in place by a $\frac{1}{4}$-inch steel pin *w*. After enough of the core has been rammed around the boss and its wing to hold it in place, the pin *w* is withdrawn and the entire core is rammed. The bosses *r* and *s* are molded with a square-cornered base *x* so as to form a block that can be held in place by a pin *x′* passed through the wall of the core box from the outside. When the core box has been rammed up, the pin *x′* is withdrawn, which frees the bosses from the box so that they will remain in the core while the box is being lifted away. The pattern for the boss *t* is held by the pin *y*. The bosses can be picked out of the core and replaced in the box. Wooden master patterns are made for each draw-back and the aluminum castings are made from them. These castings are then fitted to the core boxes.

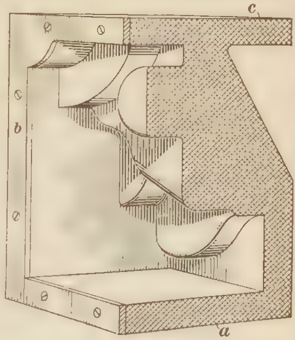


FIG. 22

35. Core Box for Outside Core.—The core box for the outside core *l*, Figs. 17, 18, and 20, is shown in Fig. 22. This box is cast of aluminum from a wooden master pattern having double shrinkage and $\frac{1}{64}$ inch for finish on the inside faces. The walls of the box are made $\frac{1}{2}$ inch thick. The top face *a* is machined $\frac{1}{8}$ inch low, so that a $\frac{1}{8}$-inch steel plate *b* can be fitted to the surface to withstand the wear. A projection *c* is added to the bottom of the box so that the box will stand level on the table, or a steel plate, while the core is being rammed up. A number of these core boxes are usually fitted to a steel plate so that several cores may be rammed at one time.

STOVE PATTERNS

MODELS, TOOLS, PATTERNS, AND PROCESSES

STOVE MODELS AND DRAWINGS

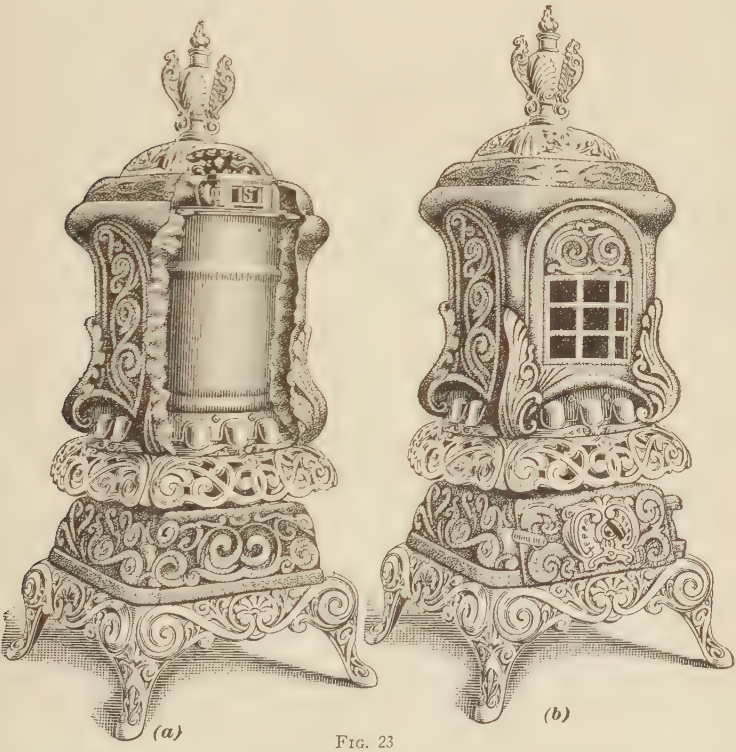
36. Stove Models.—When a manufacturer desires to bring out a new design of stove, the general scheme is usually first developed in the form of a drawing, but before deciding definitely on the exact form of the stove, a model is sometimes worked up in clay or plaster. This enables the designer to study the exact outline of the stove and see just how the various parts will fit together, and especially to study the general artistic effect. This method of procedure is especially advantageous in the case of heating stoves or stoves having considerable ornamental work on them. Plain work, such as that on cook stoves and ranges, is generally carried through without making a model. Wherever possible, the completed patterns are assembled into the stove structure so as to show the general appearance of the stove, and to aid the patternmaker in checking the accuracy of the patterns.

In case the design is made by remodeling an existing design, many of the castings of the old design may be worked into the new one.

37. In Fig. 23 is shown a stove in the process of being modeled. It will be noticed that some of the castings, such as the base and top, have a finished appearance, which indicates that they have already been decided on, and used in the model. For the purpose of supporting the body of the model a sheet-iron drum is used. Sometimes it is necessary to model only one-half of the stove, especially in round work or in work that has two or more sides alike. The clay is applied as shown in view (*a*). In view (*b*) are shown the two sides of the stove completely modeled. A specially prepared clay that dries very slowly is used for the modeling. After the model is completed,

the drawings, which are usually only partially worked up first, are finished, and the patternmaker makes the patterns or completes those that are not already made. The modeling is usually done by a specialist in this work, who may also be a good draftsman.

38. Stove Drawings.—Stove drawings are generally made full size, and differ in a great many respects from ordinary



(a) (b)

FIG. 23

mechanical drawings of machinery. A good grade of detail paper that is but slightly affected by the moisture in the atmosphere is selected on which to make the drawings. The plan is usually laid down first, and from this the sections and elevations are projected and drawn as the idea develops. All the views are placed on top of one another; that is, the elevations

and sections are all drawn on or across the plan. The result is that only a person thoroughly familiar with stove work can read one of these drawings rapidly. Usually the different sections are colored differently, and, as a rule, no dimensions whatever are put on the drawing.

39. Most mechanical drawings have to go into the machine shop to have the machine made, some of the drawings going first to the pattern shop and some to the forge shop; but a stove drawing goes to the pattern shop only, where the patternmaker prepares the patterns directly from the drawing. Wooden master patterns are first made, and from these the iron working patterns are cast, which serve for making the final castings of the parts of the stove. On this account, at least double the shrinkage usually allowed for castings must be allowed on the original master patterns. In this work the stove draftsman uses a rule that gives the proper shrinkage, so that the pattern-maker simply has to make the patterns the same dimensions as the drawing.

TOOLS FOR MAKING STOVE PATTERNS

40. Shrink Rules.—The working patterns are all made of metal, and the metal patterns are generally made from the original wooden master pattern, although in some cases a metal *reference pattern* is made from the master pattern, and from this the working patterns are cast. It is therefore necessary to make the original wooden patterns with more than the usual cast-iron shrinkage allowance, or with more than one shrink. In some cases the reference patterns are made from white metal, which shrinks only one-half as much as iron, necessitating the use of a set of shrink rules called *half-shrink rules*. In order to be able to make any kind of pattern that may be called for, a stove patternmaker should have five rules, and may have as many as seven. In case seven are used, there is one standard rule graduated to 16ths of an inch, besides the following shrink rules: $\frac{1}{2}$ shrink, 1 shrink, $1\frac{1}{2}$ shrinks, 2 shrinks, $2\frac{1}{2}$ shrinks, and 3 shrinks. In this connection a shrink is understood to mean the amount of shrinkage per foot in cast iron, which is $\frac{1}{8}$ inch. To produce the $\frac{1}{2}$-shrink rule, a space that is intended to represent

12 inches would be made $12\frac{1}{16}$ inches long, standard measurement. This would be divided into 12 equal spaces to represent inches, and these subdivided into 16ths. In like manner, any of the other shrink rules would be made by taking 12 inches plus the shrinkage allowance and dividing it into 12 parts and these into 16ths. These shrink rules are usually at least 24 inches long and are made of wood.

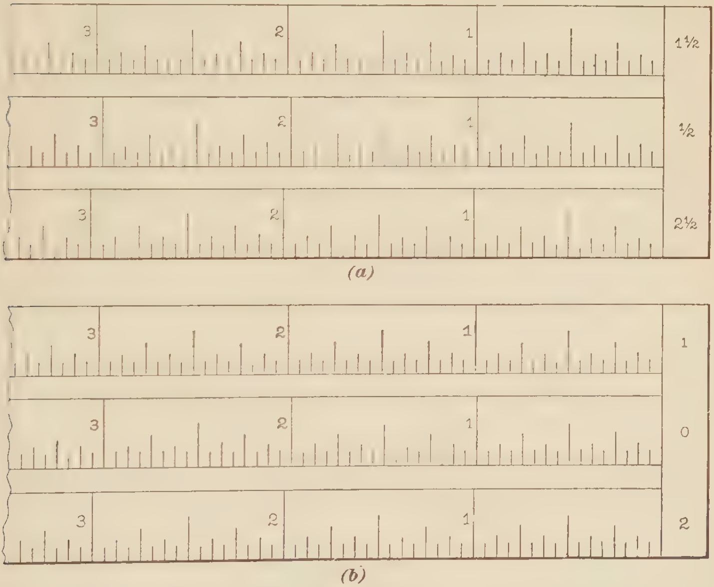


FIG. 24

41. Most of the measurements in stove patternmaking are taken by means of a pair of trams from the shrink rules; hence, the end of the rule is allowed to project beyond the graduations, as shown in Fig. 24, which illustrates a set of five shrink rules and a standard rule all made on one piece. In (*a*), the upper rule is made for $1\frac{1}{2}$ shrinks, the next $\frac{1}{2}$ shrink, and the bottom one for $2\frac{1}{2}$ shrinks. The back side of this rule will be graduated as shown in (*b*), the upper scale being for 1 shrink, the center scale a standard rule, and the lower scale for 2 shrinks. To avoid confusion, however, it is best to have each of the rules on a separate piece.

42. Stove Bevels.—Where the various plates that compose the stove are united, the edges of the plates are usually beveled. One plate has to be beveled so as to match the bevel of the other, so that they may come together properly. Stove patternmakers use a set of bevels, or gauges, so that these bevels shall be uniform. A set of eight bevels have come into quite extensive use. The first four are numbered 1, 2, 3, and 4, as shown in Fig. 25 (*a*). The space between the No. 1 bevel and the vertical line *a* is divided into five equal spaces, thus giving four more bevels, which are made and numbered *0, 00, 000,* and *0000,* as shown in (*b*). The bevels are shown with the angle of each bevel marked in degrees. For convenience in use, these bevels are ordinarily made of thin wood or metal pieces similar to the triangles used in making mechanical drawings and of any suitable size. The two in most common use by stove patternmakers and draftsmen are here shown. In using the bevel,

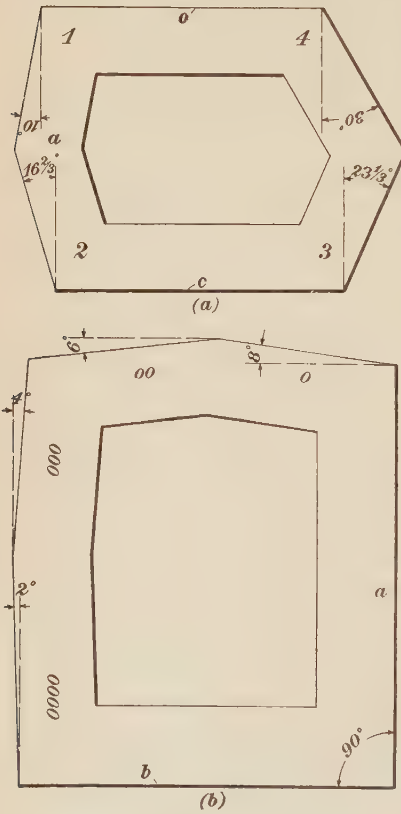


Fig. 25

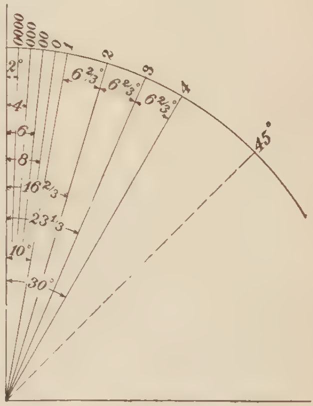


Fig. 26

view (*b*), the draftsman places one of the straight sides *a* or *b* of the gauge against a **T** square and then draws the desired lines along the bevel side corresponding to the bevel he wishes to use. In the form shown in (*a*), the two opposite sides *o* and *c* are parallel and are used against a **T** square in laying off the bevels. The number of the bevel only is put on the gauge; the degrees have been added in the illustrations to make clear the angle of each. Fig. 26 shows how the angles would look if laid off successively from the least to the greatest.

43. Stove-Patternmakers' Curves.—In a great deal of stove work, especially in heating stoves, the surfaces are curved. These curves are usually regular curves, but as it would be very inconvenient to use trams in constructing these curves, a set of

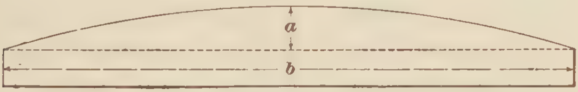


FIG. 27

curves drawn with standard radii are used. These curves have arbitrary numbers as follows: $2\frac{1}{2}$, 3, 4, 5, 6, 7, 8, 9, and 10. They are usually made with the general form shown in Fig. 27. The length *b* is the same on each one of an entire set, while the distance *a* has values that are different on each one, varying according to the radius of the desired curve. The value of *a* is greatest on No. $2\frac{1}{2}$ and least on No. 10. On a set actually measured, *b* was $22\frac{15}{16}$ inches and *a* was 2.28 inches for No. $2\frac{1}{2}$, 1.86 inches for No. 3, 1.34 inches for No. 4, 1.09 inches for No. 5, .91 inch for No. 6, .81 inch for No. 7, .69 inch for No. 8, .61 inch for No. 9, and .55 inch for No. 10.

These curves may be made from thin wood or from sheet metal. It is best to make them of metal on account of the fact that metal is not so liable to change its shape. Like the bevels, they are used by both the draftsman and the patternmaker.

44. Vertical Plumb.—In stove patternmaking it is frequently necessary to draw a center line over an irregular surface, and in order to do this a device known as a *vertical plumb* is used. This is illustrated in Fig. 28 (*a*), and consists of two

boards *a* and *b* secured to each other at right angles and held in position by braces *c*. The outer faces of the boards *a* and *b* are carefully planed at right angles to each other. For use in connection with the plumb, two wooden parallel blocks *d* are provided. The casting or pattern on which the center line is to be placed is laid between the parallel blocks and under the board *b*. A special scriber, as shown at *e*, is used for drawing the center line. This scriber consists of a piece of hard wood *e* with a steel scribing plate attached to the end, as shown at *f*, view (*b*). By means of this device it is possible to draw a

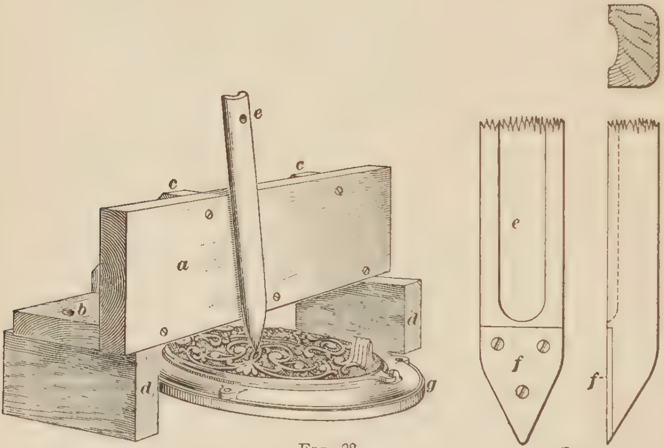


FIG. 28

straight center line across a piece of work, no matter how irregular it may be, or how much carving there may be on its surface.

45. Thickness and Marking Calipers.—Stove patterns must be carved very thin, and it is necessary that the patterns be of uniform thickness throughout, for if this is not the case, some parts of the casting will cool more rapidly than others and result in the springing or cracking of the casting. Most stove-plate work is more or less irregular in outline, and in order to make sure that the thickness at different points is the same, various forms of calipers are in use for measuring the thickness.

Fig. 29 (*a*) shows a stove-patternmaker's caliper that consists of two brass castings joined together like a pair of ordinary shears. The measuring is done between the points *a*, while an adjusting screw is placed in the end of one handle, as shown at *b*. This screw *b* is so adjusted that when it comes in contact

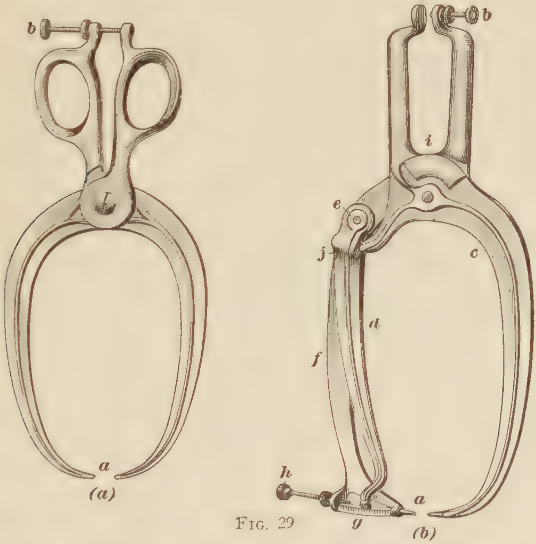


FIG. 29

with the other handle, the points at *a* will stand at the desired distance apart. By passing the points *a* over the work, the patternmaker can see what parts have been brought to the desired thickness. Any parts that are not thin enough will prevent the screw *b* from coming in contact with the other handle and so indicate what portions of the pattern must be carved thinner.

46. For somewhat more accurate work, a pair of calipers of the form shown in Fig. 29 (*b*) may be used. These calipers are made of aluminum, and are provided with steel measuring points *a*. As in the previous case, an adjusting screw *b* is provided at the end of one of the handles. A spiral spring is located in the pocket *i* and keeps the points *a* of the calipers apart unless they are brought together by hand. This caliper

is also provided with an attachment for indicating the exact amount of excess thickness at any point. This is done with an extra arm shown at *d*, pivoted at *e* to the arm *f* of the calipers. A projection on the arm *c* comes in contact with the arm *d*, and a spring located at *j* keeps the arm *d* in contact with this projection. As the points of the calipers are brought together, the point *g* of the arm *d* is forced along the graduated scale shown on the end of the arm *f*. An adjusting screw *h* is provided for stopping the arm *d* when the points at *a* are the desired distance apart. The leverage is so arranged that the point *g* moves several times as far as the point *a*, and, as a consequence, it will indicate small variations in the thickness of the pattern.

47. When the front side of a stove pattern is carved and it is necessary to back it out, that is, cut out, the back of the pattern, it is convenient to be able to trace the carved design on the back of the pattern. In order to accomplish this, a

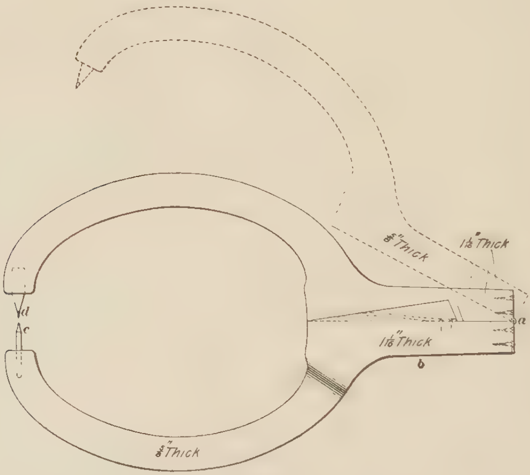


FIG. 30

pair of marking calipers, as shown in Fig. 30, is used. They are made of hard wood and are joined with an ordinary hinge at *a*. The hand grasps the two pieces at the point *b*, with sufficient pressure to bring them together, although a flat spring in the joint tends to keep them apart. The point of one caliper

leg is provided with a steel tracing point *c*, and the other is provided with a lead pencil *d*. By following the outline of the carving with the point *c*, and keeping the pencil *d* in contact with the back of the pattern, the outline of the carving can be trans-

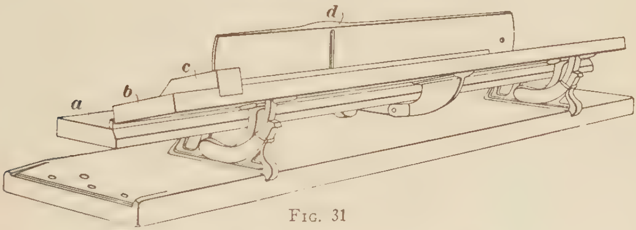


FIG. 31

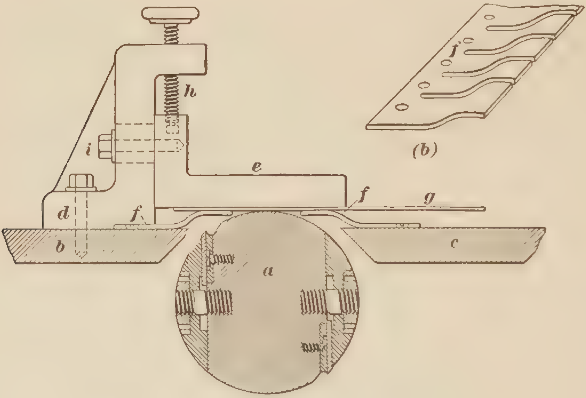
ferred from one side of the pattern to the other very quickly and accurately.

48. Chute Board.—Many portions of a stove pattern must be joined on a bevel, and as the pattern stock is very thin, it is extremely difficult to plane the edges of the pieces to the proper bevels without some special device for holding the work. To accomplish this, the chute board, one form of which is illustrated in Fig. 31, is usually employed. It consists of a flat board or gauge *a* on which the plane *d* slides, resting on its side, as shown in the illustration. An inclined board *b* is so arranged that it can be adjusted to make any desired bevel with the board *a*, and a stop *c* is provided to hold the end of the work. The stock to be operated on is laid on the board *b*, brought against the stop *c*, held there by hand, and the edge that projects from *b* is dressed to the desired bevel by means of the plane *d*, which is passed back and forth while in contact with *a* and the stock.

49. Carving Tools.—In stove patternmaking, a large amount of carving is necessary, which could not be done advantageously with the chisels ordinarily used in patternmaking. Hence, the stove-pattern maker has to provide himself with a set of carving tools, which usually consist of small gouges, paring chisels, and gravers. In large stove-pattern shops the carving is usually done by skilled carvers, and in some cases a stove

pattern passes through the hands of three or four carvers, each doing his own special work.

50. Planer Attachment for Making Thin Stock.—In stove patternmaking it is necessary to use a great deal of very thin stock, some of it being less than $\frac{1}{12}$ inch in thickness. To produce this thin stock on an ordinary planer, some special attachment is necessary, and the one shown in Fig. 32 has been used very successfully. At *a* is shown the cutter head of the planer, and at *b* and *c* the planer tables. On each side of the table *b*, an angle bracket about $2\frac{1}{4}$ inches wide, shown at *d*, is



(a)

FIG. 32

fastened, and between the two angle brackets the angle plate *e* is supported. This angle plate is clamped to the brackets by the clamp screws *i*, and can be adjusted vertically by two $\frac{3}{4}$-inch adjusting screws *h*. The stock *g* being operated on is held in contact with the angle plate *e* by springs *f* attached to the tables *b* and *c*. An enlarged view of one of these springs is shown in (*b*). It consists of a piece of spring steel that is shaped to the desired form and tempered. The edge of the spring is split in such a way as to form a series of carrying springs, each about 1 inch wide, which hold the work in contact with the angle plate *e*. By this device it is possible to plane

thin stock smoothly to a uniform thickness with very little trouble, and the form of the attachment avoids all danger of injury to the workman's hands.

CHARACTER OF STOVE PATTERNS

51. Comparison of Stove and Machine Patterns.—Patterns for machine parts are usually thick and substantial enough to support themselves. The skilful application of the principles of joinery in the production of the desired form plays an important part in the work of a machine-pattern maker. Stove patterns, on the other hand, are usually very thin and must be practically of uniform thickness throughout, and as a consequence such patterns require special treatment. Stove patterns are rarely strong enough to support themselves; hence, for all but small parts of the stove it is necessary to have a *match* or support for the wooden pattern for use while making the metal pattern. In many cases the match is made first and the wooden pattern is then made on the match. These patterns frequently have a large amount of carving on them. Stove patternmaking, therefore, differs greatly from machine patternmaking and is a peculiar branch by itself. There are, however, many points concerning stove patternmaking that the machine pattern maker could use to advantage when making thin or intricate machine patterns.

52. Materials Used for Stove Patterns. The original pattern used for stove work is usually made of wood, but in some cases it is modeled in clay or plaster. The working patterns are generally made of cast iron. In case the master pattern is of such a form that a reference pattern must be made from it and this in turn is used to make the working patterns, the reference pattern is usually made of either cast iron or of white metal. This white metal consists of 9 parts of lead to 1 part of antimony, and has a shrinkage of $\frac{1}{16}$ inch per foot. Particular attention is called to the fact that, in order to obtain uniform results, one brand of lead and one brand of antimony must be adhered to, as different brands have different physical properties. It does not make so much difference what brand is

adopted, but the brand first adopted should be adhered to in order that the shrinkage may always be the same. The master and reference patterns should be kept in fireproof vaults, as they are the ultimate standards of reference.

PROCESSES USED IN MAKING STOVE PATTERNS

53. Backing Process.—A common method of making stove patterns, called the *backing process*, is to carve out the back so that the pattern is of uniform thickness throughout. Backed-out patterns generally require a support on the follow board while molding; but if the pattern is small, like a stove leg, the pattern may be tucked up in green sand and the iron working pattern made directly from the wooden master pattern. In case of large patterns, it is necessary to carve the support on the follow board so that it will fit the pattern at practically all points. In case of work such as stove bases, the support is usually made first and the parts of the pattern are built on it. The pattern joints are glued and the pattern is kept in contact with the pattern board throughout all the work. The support should be oiled under the glued joints of the pattern to prevent the glue from sticking to it. After the pattern is completed and the working patterns are made from it, the follow board and wooden master pattern are stored for reference. The backing process is illustrated in connection with patterns described later on.

54. Blocking Process.—In order to avoid the work of backing out a pattern, as in the backing process, a system is employed in which the face of the pattern is carved and finished to the desired shape, and blocked on a board so that a drag can be rammed up from it. This drag is then used as a match, and a cope is rammed up in the usual manner. While the original drag was being rammed, the pattern was surrounded with a thin layer of blocking just the thickness of the desired casting. This blocking is removed and another drag rammed up to be used with the cope already made. By this method the pattern is made to project farther from the molding board in the second case, so as to produce the required thickness of metal. This process, called the *blocking process*, is illustrated in connection with a stove pattern later on.

55. Wax Process.—In some cases, in order to avoid backing out the pattern, one side only is carved, and from this a plaster-of-Paris cast is made. The pattern is then built up by pressing a layer of plastic material on the plaster cast. This is usually accomplished by rolling clay into a thin layer of the desired thickness, cutting it into small strips and pieces, and fitting these over the area covered by the pattern. After the pattern has been built up in clay on the plaster match, the surface of the plaster and the clay is prepared with oil, and the other half of the mold poured in plaster. The two portions of the plaster mold are then taken apart and the filling material is cleaned out. Gates and vents are cut, and a hard-wax pattern is made by pouring the space between the halves of the plaster mold full of melted wax. After this, either half of the plaster mold may be used as a match board to support the wax pattern while ramming the sand mold for a metal pattern.

EXAMPLES OF STOVE PATTERNMAKING

BASE PANEL BY THE BLOCKING PROCESS

56. Block Pattern.—The blocking process is frequently used for producing metal patterns, because it is more simple and requires less work for the patternmaker. However, this process requires more work on the part of the molder than the backing process.

The first outline pattern made of wood is called a block pattern, and is made with a double shrink. The drawings for such patterns should be made with measurements taken from a 2-shrink rule, as this will greatly simplify the work of the patternmaker, who also uses a 2-shrink rule. For the block pattern, the best of pine should be chosen.

57. Preparing the Block.—If a pattern is to be made for the casting shown in Fig. 33 (*a*), a block must first be built up to form the stock from which the pattern is worked out. The block is composed of pieces of wood glued together as shown by the dotted lines in (*b*) in order to keep the pattern from warping. Sometimes the material from which the pattern is built is laid up parallel to the sides *ab*, but by this method there

is a greater tendency to warp. After the glue has dried, the block is squared up on all sides and is then ready for the outline of the design. Before the carving can be done the block must

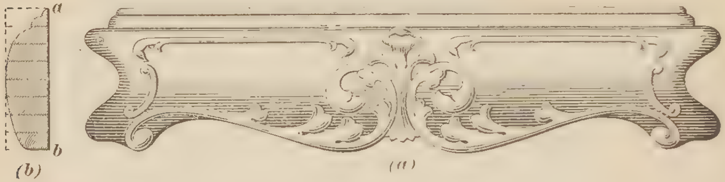


FIG 33

be dressed to the shape of the casting profile as shown in (*b*). In order to profile the block accurately, a templet should be made of thin wood or metal. This is done by laying out the desired outline on the templet from the full size drawing, and cutting to the lines thus made. The templet is then used to lay out the form on each end of the block which is worked off to the required shape and is then ready for the ornamentation. This may either be carved into the surface of the block or built up on it.

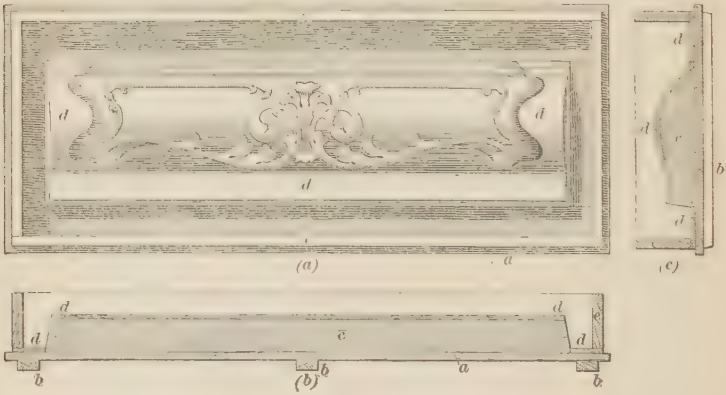


FIG. 34

58. **Finishing the Wooden Pattern.**—When the ornamentation is completed, three coats of shellac are applied to the surface of the pattern. After the first coat of shellac has dried and been sandpapered, the brad holes and other small holes are

filled with beeswax, and the second coat of shellac is applied. When that is dried, the surface is again shellacked and lightly sandpapered, which is the final operation. The block pattern is then ready for the molder to make the metal pattern.

59. Preparing Pattern for Reversing.—The term *reversing the pattern* means the process by which the molder changes the block pattern into an iron-shell pattern of uniform thickness. The first step in the process is the making of the pattern board, as shown in Fig. 34. The pattern board *a* is made enough

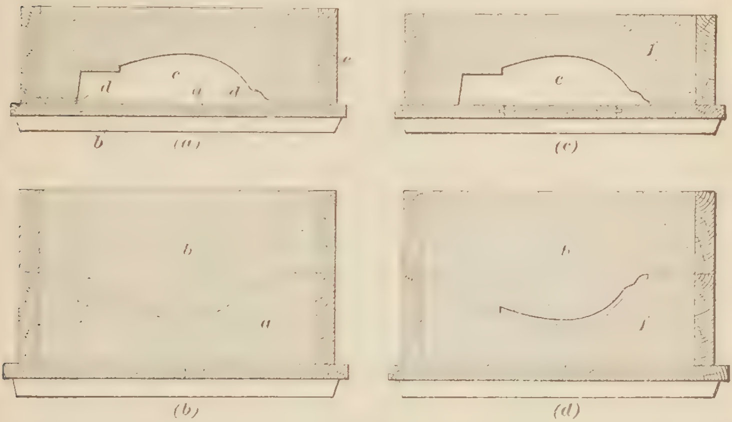


FIG. 35

larger than the pattern block to leave a margin of 2 or 3 inches all around, as shown. The board is made of $1\frac{1}{2}$-inch material with three cleats *b* nailed to the back. The surface of the board is trued up and the pattern block *c* screwed to it. Thickening strips *d* equal to the thickness of the metal pattern are fitted around the pattern and the pattern block.

60. Mold for Reversing the Pattern.—In order to make a mold by the use of a block pattern, it is necessary for the molder to make two drags. One drag is made with the use of all the thickening strips and the second is made without them. The first drag is used only when ramming the cope.

The method of making the mold is shown in Fig. 35. A drag flask *e* is set over the pattern *c* on the board *a*, and on top of the

thickening strips *d* and rammed up, as shown in (*a*). The drag is reversed, the pattern *c* and strips *d* are removed, parting sand is applied, and the cope rammed up. The mold then appears as in (*b*). The cope *b* is set aside, while the drag *a* is shaken out and the same flask is used to make a new drag off the pattern without the thickening strips. The removal of the thickening strips lowers the flask an amount equal to the thickness of the casting. Therefore, this second drag appears as at *f* in view (*c*). The drag *f* is reversed and the cope *b* set on as in (*d*).

61. Error from Thickening Strips.—The use of thickening strips with a block pattern having vertical or curved surfaces produces a mold that does not have a uniform thickness of space for the casting. This is illustrated in connection with Fig. 36. The curve *abc* of the drag and the curve *def* of the cope are both made from the same block pattern. By the use of the thickening strips the depths of these curves differ by a distance *eb* equal to the desired thickness of the casting. Separating these two equal curves vertically does not, however, separate them the same amount on the sides, as shown in the illustration.

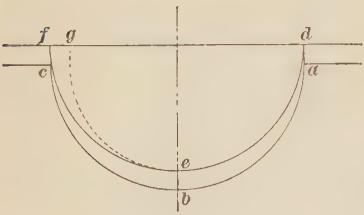


Fig. 36

In order, therefore, that there may be a uniform thickness of space between the two curves, it is necessary for the molder to shave off the cope curve, as shown by the dotted curve *eg*. The other side *ed* must be shaved, of course, in the same way, so as to make the width *fg* of the space around the edge of the casting equal to *eb*.

62. Finishing Metal Patterns.—After the metal pattern is cast it is finished smooth by filing and scraping. To protect the pattern against rust, and also to give it a smooth surface that will allow it to be easily removed from the sand mold, a coating of beeswax may be applied. This may be done by heating the pattern just enough so that when the wax is rubbed over its surface the wax will melt and adhere to the surface of

the pattern. After the wax is applied it may be rubbed over, thus removing the excess wax. When the pattern has become cold it may be polished by rubbing with a stiff brush. This waxing will give a good working surface to any iron pattern.

63. Metal Pattern Support.—A follow board is necessary for all thin metal patterns having irregular surfaces to keep them from springing during the molding. A plain molding board is first made and on this are built the projections required to fit the under side of the pattern. This will convert the plain molding board into a follow board. To get a bearing on the projections, blue chalk or some other suitable marking material is applied to the under side of the pattern. The pattern is then placed on the built-up projections, and wherever the pattern touches, a mark will be made. The points covered by the marks thus made are worked down, and the operation is repeated until a good bearing is obtained.

STOVE-LEG AND BASE PATTERN BY BACKING PROCESS

64. Preparing Stock.—The block should be made of 1-inch stock glued together, as indicated by the parallel lines in Fig. 37. When the block is made and squared up on all sides, it is to be split diagonally with a saw and glued together as shown by the dotted line *ab* in (*b*). The reason for splitting diagonally and glueing together is to establish a center line all through the block for convenience in making measurements. No matter where a cut is made in shaping the face of the pattern, the diagonal joint line will be present as a center line.

65. Forming the Leg Pattern.—Having prepared the block for the pattern, lay off the outline of the stove leg on two faces that are at right angles to each other. Each surface will then appear as shown in Fig. 37 (*a*). Now saw to the lines laid off on one face, and when the two pieces are cut away, replace them securely to the block, using two or three spots of glue.

The replacing of the pieces gives a flat surface to rest on the saw table while sawing to the outlines on the other face. After the sawing is completed and the pieces are all removed the piece will appear as shown in (*c*).

The sides of the leg must be shaped to fit the ends of the base panels.

In shaping the outside of the pattern, care should be taken to leave the proper thickness of stock for carving the ornamental part, which should be about $\frac{3}{16}$ or $\frac{1}{4}$ inch. The depth of the carv-

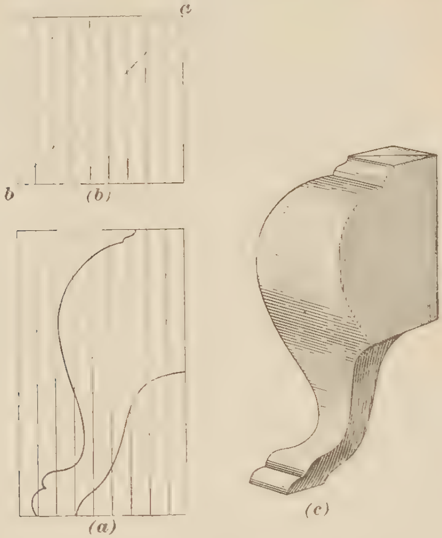


FIG. 37

ing cannot be as great on a leg as on the panel, on account of its shape, which makes it difficult to give draft to deep carving.

66. Backing a Stove-Leg Pattern.—The term *backing* comes from the method of making the pattern by carving out the back, as shown in Fig. 38, thus making in wood a finished master pattern having a uniform thickness. The front of the leg is carved first, as shown at *e*, in (*a*). The back, shown at *f*, is next to be carved. At *d*, view (*b*), the same pattern is shown partly backed out, and in (*c*) the backing has been completed. The pattern is held as shown in Fig. 39 during backing out. From experience the patternmaker learns what tendency such castings have to warp, and he overcomes the warping by giving the pattern an opposite curve. The marking calipers are used to trace the figure of the carving on the back from the front.

When the back is carved as near to the correct size as can be judged by the eye, the thickness calipers are used to locate any thick places, which are then brought to the required thinness. After this pattern has been completed, a white-metal master pattern is made, from which the iron patterns are molded and cast.

67. Base-Panel Patterns.—The stock for the front base panel is glued up and worked to the general form of the panel, as described in Art. 64. Allowance for carving must be made

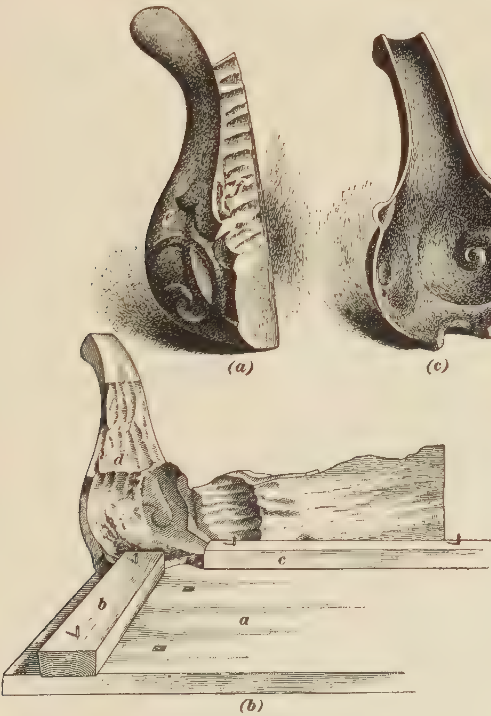


Fig. 38

when working the block down to the general shape of the panel. The front panel of the base is carved out in the same manner as the leg, as is shown at Fig. 40 (*a*). This must be trimmed around the outside, which is usually done on a band saw or a jig saw, and then backed out in the same manner as

the stove leg. In (*b*) is shown the back of the same panel, showing how the pattern is backed out to the outline of the front or face side. This panel is fitted to the leg patterns by rubbing blue chalk on one pattern and then rubbing the patterns together to show where the trimming must be done to bring

FIG. 39

them to a good fit. The device shown in Fig. 38 (*b*) will be found useful in doing this work. It consists of a base board *a* on which two strips *b* and *c* are secured at right angles to each other. The leg is placed at one corner, as shown at *d*, and the panels are placed against the strips *b* and *c*. The use of this device secures not only an accurate fit, but makes it easy to produce a base with square corners.

PATTERN FOR FRONT JAMB OF RANGE

68. Preparing the Pattern Board.—The front jamb of a range is the part where the oven door is located. Such a jamb is shown in Fig. 41, with the elevation in (*a*), a section on *ab*

in (b), and a section on cd in (c). The first step in the process of making the pattern for this jamb is to make a pattern board, on which the pattern is to be fastened, $3\frac{1}{2}$ inches larger all around

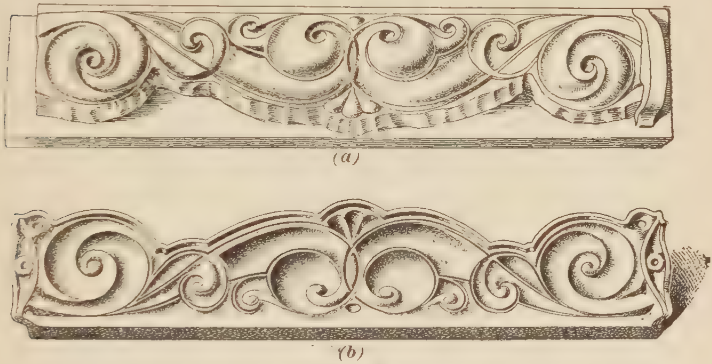


FIG. 40

than the pattern. This board should, if possible, be made of $1\frac{1}{8}$-inch pine boards 5 inches wide, that have been thoroughly seasoned or kiln dried. If wider pieces are used, saw cuts should be made two-thirds of the way through the boards and sufficiently close together to allow the board to be bent easily to

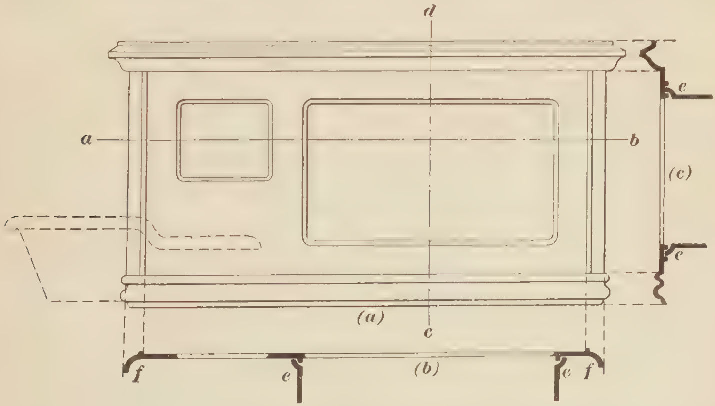


FIG. 41

the desired shape. Three cleats are then nailed to the boards, five nails being used to fasten each board to each cleat, as shown at a, Fig. 42 (a).

69. The casting made from a straight pattern often comes out warped or with a bend in it, and so it is sometimes necessary to bend the pattern in the opposite direction so that the casting will come out straight. In such a case the mold board shown in Fig. 42 (*b*) is arranged with bolts *b* through the cleats and

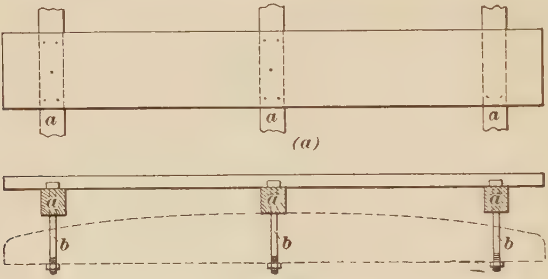


FIG. 42

pulling against a curved piece shown by the dotted lines, so as to give the mold board the desired shape. This same method is used to prevent the pattern from warping after coming in contact with the wet sand. Before putting the pattern together on the pattern board, the pieces are all prepared so that they may be put on in a short time.

70. Preparing the Moldings.—A number of thin pieces, 4 inches wide and $\frac{1}{10}$ inch thick, of different lengths, are prepared, special care being taken to have all the thin parts just $\frac{1}{10}$ inch thick. The straight moldings for the sides and ends are then made, and a piece of the same cross-section is turned for the corners. This is done for each different style of molding, and the turned pieces are each cut into four pieces. Each turned piece is made as shown in Fig. 43 (*a*), in which *a* shows the entire piece, and *b* a half-section of it. The pieces *a* are then cut into quarters along the lines *cd* and *ef*. One of these quarter pieces can be used as a templet by which to lay out the straight moldings.

71. To make the straight moldings, prepare pieces of the proper length, thickness, and width, according to the dimensions given on the drawing. Lay the templet on the end of

the piece, mark around it with a fine hard pencil, as shown in Fig. 43 (*b*), and work off the outside to the shape thus marked, by means of saw, rabbet plane, rounds, and gouges. Then work out the inside by the same process, being sure to have even thickness throughout.

In order to prepare the match to fit these pieces, take rectangular strips and mark them on the end with the inside of the moldings, and fit the moldings to them until they will fit the templet corner when laid in the proper position. Next make the flanges shown in (*c*) and (*d*). The flange in (*c*) sup-

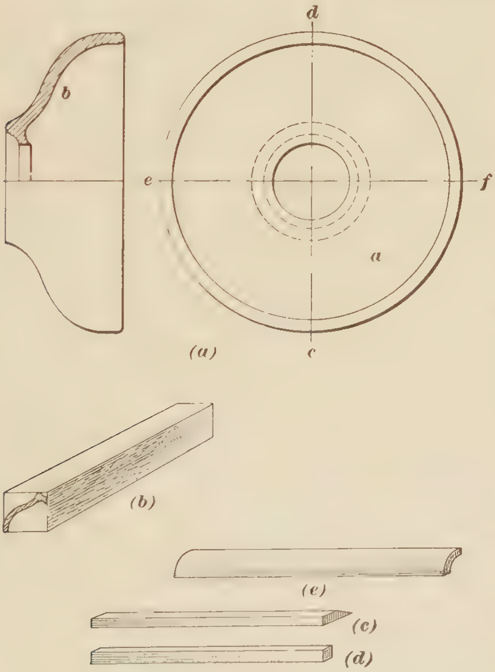


FIG. 43

ports the flue strips, and the one in (*d*) goes around the oven-door opening, as shown at *e*, Fig. 41. Then make the corner moldings as shown in Fig. 43 (*e*), also shown at *f*, Fig. 41.

To construct the pattern, take the board, prepared as already described, and plane it up perfectly true. Make one edge per-

fectly straight, so that it can be used for a working edge; then any number of lines can be drawn parallel, which is very essential to a true pattern. These parallel lines can be laid off at right angles to the true edge and scribed with a sharp knife.

72. Making the Match and Pattern.—The match is now built up on this board of the exact form of the under side of the pattern. Start with the corners, which are laid out carefully and follow with the moldings that have been fitted to the inside of the molding of which the pattern is to be made. When the match is finished, it is oiled all over, and the pattern proper is built up of the moldings that have been prepared and any flat pieces of the same thickness that may be necessary. They are glued together on the pattern board, and hence the pattern always fits the match. The oil on the match prevents the glue from causing the pattern and match to adhere with any great tenacity.

73. When the pattern is put together, it is sandpapered, coated with shellac varnish, and sandpapered again. Beeswax is then put into any small holes, and two more coats of shellac are given the pattern. It is now finished, having a hard, smooth surface, and is ready for the molder. In making the iron pattern, the molder uses the wooden match to support the wooden pattern while ramming up the drag. If it is necessary to have the finished iron pattern curved to make the castings come out straight, it will be necessary to construct the wooden pattern with double the amount of curve necessary in the iron pattern, as the iron pattern will spring in cooling just as a casting would. After the iron pattern is made and finished, a wooden match board is made for it.

MAIN TOP OF RANGE

74. Preparing to Make the Pattern.—The main top of a range or stove is made in one casting, although it is often found to be of advantage to have the pattern in parts, so that by different combinations of parts a variety of tops may be available without having a separate pattern for each. Fig. 44 shows the iron pattern of a range top; in (*a*) the top side is shown, and in (*b*) the under side. The first pattern for this top is some-

times made entirely of pine. The different parts are prepared before the pattern is put together in a manner similar to that explained in connection with the range jamb. The match is prepared in a similar manner, the corners and moldings being built up to the exact form of the under side of the top. This is smoothed off and oiled, and the pattern is glued together on the board, giving it a good bearing at every point. It would be impossible to make the pattern first and then build a board to fit the pattern accurately without a great waste of time.

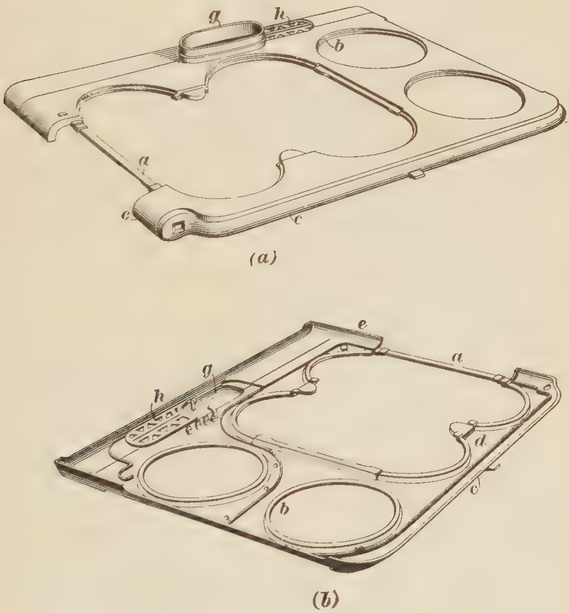


FIG. 44

75. Description of Parts.—Range tops are often made in four sizes, according to the sizes of the holes in the top and to the size of the oven of the range for which the top is prepared. They are made of a uniform thickness, as, for example, $\frac{1}{8}$ inch in all sizes. The front end of the top is where the broiler door is located. Flanges are placed on each side of the opening for the broiler door, and are connected in the pattern with a wooden bar called a *splice*, as shown at *a*, Fig. 44. The bar is

also cast in the iron pattern and in the final casting. Its object is to prevent the end of the casting from spreading. After the casting is cool, the bar is broken out. The splice is merely for the purpose of holding the pattern in shape. The rabbet shown at *b* is the cover seat, which is depressed below the main body of the top. The moldings *c* on the edges are made separately and fastened on. The small ribs *d* are for the side plates to butt against. The front moldings *e* are fastened on in a

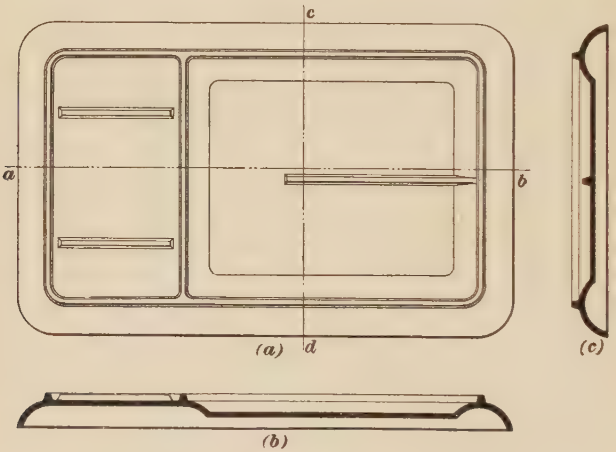


FIG. 45

manner similar to those shown at *c*. On the back edge is located the smoke collar *g*, and the check-damper *h*. The work of putting the parts together and finishing the pattern ready for the molder is the same as that described for the jamb pattern. The central portion of the top that contains the openings for the lids is often made separate, so that different combinations of tops or side flanges can be obtained to suit different sizes of stoves without having entire patterns for each size.

RANGE BOTTOM

76. The pattern for a range bottom is made on a match in a manner very similar to that of the other range patterns. The corners are turned and cut into quarters, as for the range top, and they are the first pieces located on the match. The main

part of the stock is $\frac{1}{10}$ inch thick and should be very uniform. The pattern appears as shown in Fig. 45, with the plan in (*a*), a section on *ab* in (*b*), and a section on *cd* in (*c*). When the wooden pattern is completed, it is placed on the match and the drag of the mold is made in the usual manner. The match is removed and the cope of the mold made with the pattern still in the drag. When the cope is taken off, the mold is finished in the usual way. Sometimes a gate is cut all around the mold for the metal to flow through, with smaller gates at intervals,

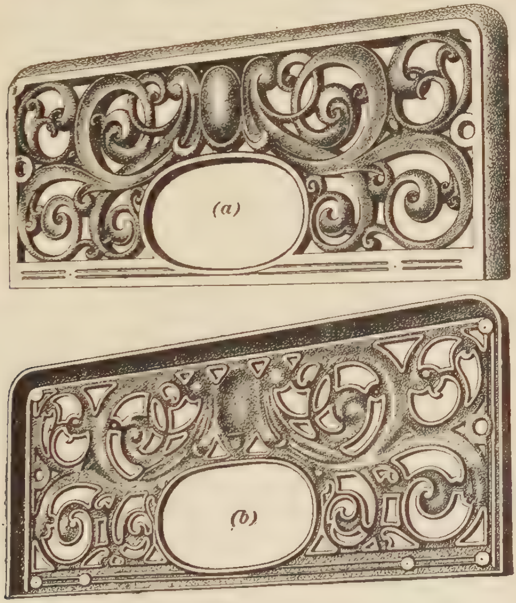


Fig. 46

to the mold. When this is done, it is not necessary to bend the pattern board, as these gates tend to keep the casting from warping. The casting may be taken out of the sand before it is entirely cooled, to be watched, and when it is bent a little more than is required, the gates are knocked off. This need only be done in making the pattern, for if that is properly shaped, the final castings should come out perfectly flat and true. Experience is the only thing that can be counted on as a guide as to the proper curve to give the iron pattern.

TOP RANGE SHELF

77. The top shelf of a range is usually rather ornamental, and therefore much carving is done on the wooden pattern. This pattern is frequently made of mahogany, and is cut out of a block formed by gluing small pieces together to prevent warping. The thickness of the stock should be about $\frac{1}{2}$ inch, in order to give good relief to the design and to allow proper backing. The design is transferred to the finished block and carved out accurately by the workman who carves the face work, and then it is backed out by a workman who makes a specialty of this work. When the pattern is finished, the pattern board is prepared with a block to support the carved part, and small blocks the shape of the molding are placed all around the curved edge of the shelf. When the pattern board is finished, all is ready for making the iron pattern, which is shown in Fig. 46 (*a*) and (*b*). The front, or face, side is shown in (*a*), and the back in (*b*). When the pattern is finished, it should be of the uniform thickness of $\frac{1}{10}$ inch on all iron parts except the bottom edge of the molding. After the iron pattern is made, a wooden match is carved for it.

STOVE DOOR BY THE WAX PROCESS

78. The wax process involves the making of a wax pattern by casting it in a plaster mold. A block pattern is first made and carefully carved on the front face, as shown in Fig. 47 (*a*), but the back is left untouched. This pattern is fastened to a mold board, thoroughly greased, and a frame is placed around it. A mold is cast in plaster of Paris, which, when the pattern is removed, appears as shown in (*b*). Then specially prepared clay that dries slowly is rolled out with a rolling pin in a manner similar to rolling out pie crust. To aid in rolling out the clay to the required thickness, a strip of the same thickness as the clay may be placed under each end of the rolling pin. The clay is cut into strips and carefully pressed into the face of the plaster cast left by the wooden pattern, one strip at a time, until it has the right thickness all over. It is then trimmed up, any imperfections are pressed out, and the hinges and other parts

are carefully built up to the shape desired, after which a plaster cast of this is made.

79. The plaster cast forms the back part of the plaster mold, as shown in Fig. 47 (*c*), and when put together with the part in (*b*), so that the projections *a* fit the holes *b*, the mold has the proper thickness for a pattern of the desired door. The

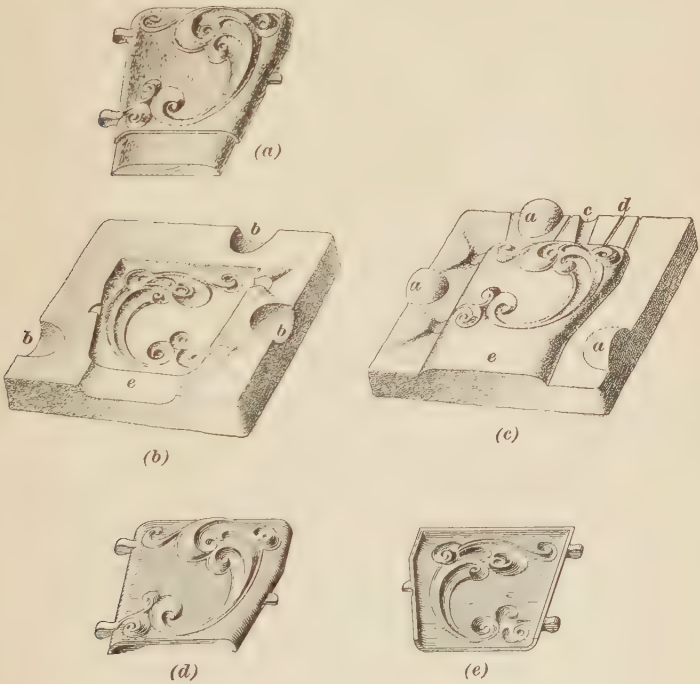


Fig. 47

part *e* in (*c*) at the same time fits into the part *e* in (*b*) so that the wax cannot run out when the mold is poured. A gate *c* and vents *d* are then cut in the plaster. Melted wax is run into this mold and takes its shape. The front face of such a wax pattern is shown in (*d*), and the back face in (*e*). The wax pattern is substantial and can be used almost like a wooden pattern. From the wax pattern a master pattern is cast in white metal by using one of the plaster-cast molds as a match in ram-

ming up the sand mold. Sometimes the wax pattern is used as the master pattern, and the iron patterns are made from it direct; but in such case the wax pattern must be made with 2 shrinks instead of $2\frac{1}{2}$, as would be needed in making a white-metal master pattern.

Considerable practice or experience is necessary to work this method successfully, but when the peculiarities of the process are mastered, it gives very satisfactory results.

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Metal pattern making.